AGENDA

CITY COUNCIL WORK SESSION
NORTH COMPLEX, CITY COUNCIL CHAMBERS, 5160 MAPLE DRIVE

March 15, 2016

5:30 p.m.

DISCUSSION TOPICS

1. Discussion of report from HDR:
   The City and Dee Zee retained the services of the engineering firm HDR Inc. to investigate the noise generated from the stamping process done at Dee Zee and what measures can be taken to reduce that noise. HDR has completed their study and it has been shared with Dee Zee. HDR and Dee Zee will have representatives at the meeting to discuss the findings with Council.

Investigation Summary Report and Recommendations

Metal Stamping Plant Noise/Vibration Investigation

City of Pleasant Hill, Iowa

March 9, 2016

This page intentionally left blank.

Executive Summary

HDR has investigated the source of noise nuisance complaints from residents of the Copper Creek neighborhood in Pleasant Hill and developed a series of recommendations for resolving the observed issues. The subject of these complaints is a metal stamping production facility operated by Dee Zee, Inc. (Dee Zee) located south of the Copper Creek neighborhood on Sloans Way.

Summary of Data Gathering and Interpretations

Residents reporting noise nuisances from Dee Zee live up hill from the Dee Zee facility (to the North and West) in the Copper Creek neighborhood. A small resident group was convened in order to interview the residents about their experiences. This group reported there are times they will experience an impulsive sound that is unvarying and apparent throughout each house, not just near a window. It is most noticeable during summer months and between the hours 9 pm and 4 am the noise is the most bothersome. Residents reported the noise is more prominent when the overhead door on the northeast side of the Dee Zee building is open. Furthermore, the residents report the noise has become worse since 2012, when a large sawdust / wood shavings stockpile on the property north of the Dee Zee facility was removed.

A survey was distributed to a number of residents to evaluate the times at which they were disrupted by sounds from the Dee Zee facility, and records of the complaints were compared to historical weather data and police report records. In general, the weather during times of complaints did not exhibit precipitation events, but did exhibit winds which are mostly calm or low speed and in a SSE/SE/ESE direction (although not exclusively).

From the resident's observations and typical weather during complaints, the conditions are consistent with downwind propagation of noise from the source and propagation during temperature inversions. Under these conditions, the sound which would normally be directed up into the atmosphere is carried from the facility and deposited into the neighborhood.

The site visit of the Dee Zee facility included exposing and visually inspecting the vibration isolation springs under the largest stamping machines (Jinan and Stamtec). While it is possible the vibration isolation springs are operating as designed, the appearance of the springs in a collapsed state is indicative of an ineffective vibration dampening product. HDR measured vibration levels from the Jinan and Stamtec machines, including points on the press, on the floor slab beside the press, and on the steel column (floor to ceiling) nearest to each press. Evaluation of resonance and coherence data from these measurements indicates the springs are not providing vibration isolation as would typically be expected from similar equipment, and there is likely very little reduction in vibration between the machines and the steel building columns at very low frequencies.

The building itself is a steel-framed structure with large unsupported sections of thin-gauge metal sheeting. Visual observations and measurement data indicate that when the ground moves due to the stamping machine, more energy will go into the flexing motion of the column

than into the vertical movement of the column. This flexing motion is likely causing flexing of the roof framing and the roof panel.

In summary, HDR believes vibration from the stamping machines is exciting the entire building to vibrate. The flexing vibration in large sections of unsupported thin-gauge metal sheeting on the building roof induces airborne sound waves into the outside environment. The extremely large surface area is favorable to produce high sound power levels, even at low efficiency rates. Opening the overhead door on the north side of the facility only serves to increase the sound emission efficiency of the building.

Summary of Recommendations

Based on evaluation of data collected during this project, we offer the following possible solutions to the observed noise nuisance from the Dee Zee facility, listed in order of preference of implementation:

1. Bring out the original equipment manufacturers to view the isolation equipment under the Jinan unit to evaluate whether the springs are performing as they were designed. As any modifications to the original vibration isolation equipment recommended by the manufacturer will require operational downtime for the Dee Zee process, at this time this option is recommended as “For Information Only”.
2. Add climate control or additional ventilation to the Dee Zee facility for use during the summer months, so that doors do not need to be opened to cool the building.
3. Enclose the two largest stamping machines in a freestanding acoustical enclosure inside the plant. This could be a freestanding metal frame with quilted and mass-loaded acoustical blanket hung from the frame.
4. Increase the acoustical isolation of the building envelope – especially the roof. This would require adding material to the ceiling (i.e. the underside of the roof) such as additional acoustical insulation and a perforated metal panel facing, or a quilted acoustical barrier.
5. Install a vegetated earthen berm north of the Dee Zee facility to act as a large expanse of sound-absorbing surface. This would make a measurable reduction in sound propagation due to the grazing-angle and the berm material sound absorption qualities. However, due to numerous unknown variables related to the impending building construction in the same location it is possible this option would not be viable without a disruption to the planned Dee Zee business operations.

The following table summarizes the identified solutions with approximate opinions of capital cost. Solutions are shown in order of implementation preference beginning with the largest noise reduction potential for the lowest cost and operational impact.

Recommendation	Approximate Cost	Comments
Equipment Manufacturer Evaluation	TBD	The manufacturer may or may not charge for this visit.
Plant Ventilation	$110,000	Cost may be less depending upon the current building ventilation capacity.
Acoustical Enclosure	$90,000	Cost may vary depending upon the structural frame, openings, and lighting/ventilation.
Roof Isolation	$480,000	Price shown is for the most obvious and effective material; however there are many other less expensive materials available, depending upon the design.
Earthen Berm Construction	$150,000	Recommend delaying this option for further evaluation once construction of the new Dee Zee metal building is complete.

This page intentionally left blank.

Table of Contents

Project Introduction 1
Dee Zee Facility Site Visit Observations 2
Building Design & Materials 2
Operations & Process Equipment 2
Surrounding Property 3
Vibration Measurements 4
Resident Perceptions 8
Resident Survey Summary 8
Resident Interview Summary 9
Neighborhood Complaints 9
Method of Noise Propagation 11
Recommend Actions 13
Sequence of Implementation 14
Equipment Manufacturer Evaluation 15
Plant Ventilation Approach 15
Acoustical Enclosure Approach 15
Roof Isolation Approach 15
Earthen Dampening Berm Approach 16

List of Figures

Figure 1 - Project Area Vicinity Map, Circa September 2012
Figure 2 - Project Area Vicinity Map, Circa October 2014
Figure 3 – Vibration transmissibility from Jinan and Stamtec stamping machines into floor slab
Figure 4 – Vibration transmissibility from Jinan and Stamtec stamping machines into normal and vertical vibration movement to nearest column
Appendix B, Figure 1, Pleasant Hill – Dee Zee Noise Observation Location Map

List of Tables

Table 1 – Resident Observations Summary Table 8
Table 2 – Table of resident complaints from police reports and from resident surveys. 9
Table 3 – Summary of Recommendations 14

List of Appendices

Appendix A: Noise Nuisance Observations Blank Log Form
Appendix B: Noise Nuisance Observation Location Map

This page intentionally left blank.

Project Introduction

Residents in the Copper Creek neighborhood of Pleasant Hill, Iowa have been actively reporting noise nuisances from the nearby Dee Zee, Inc. (Dee Zee) metal stamping facility for the past three to four years. In response to the concern of their residents, the City of Pleasant Hill (City) has engaged HDR to assist with finding a solution that mitigates the noise sources, with the aim of reducing the annoyance to residents while limiting the operational and financial impact to Dee Zee.

HDR understands that airborne noise levels near the facility comply with the City noise ordinance. Thus, the primary goal of this work did not include extensive environmental testing designed to pinpoint the magnitude of the observed noise at Copper Creek residences, but instead focused on identifying the specific source of the noise within the Dee Zee facility and developing a remedy to permanently resolve this problem for the citizens of Pleasant Hill.

A previous study of this issue was performed by Iowa State University. Their report suggested abandoned underground coal mines may be present in this area may be transmitting the ground-borne vibration through the abandoned mines to foundations of residential homes. Additional investigative work was completed by Terracon Consultants at the request of Dee Zee, which included measuring ground-borne vibration at the homes of several Copper Creek residents. Results of this investigation indicated ground-borne vibration attributable to the Dee Zee manufacturing process was not observed during the time period measurements were taken.

To collect data for this project, HDR requested specific information from Dee Zee, including identifying the machinery, materials, and processes used in their manufacturing, as well as details of the building construction and soil conditions under the foundation. Dee Zee provided full details for most of the requests, however details of the soil conditions were not available and were therefore not provided. This information was obtained through other publicly available records.

As a supplement to the observations and quantitative data measurements obtained during the Dee Zee site visit, the City distributed observation logs to residents in the neighborhoods surrounding Dee Zee and returned the completed logs to HDR for evaluation. The City and HDR additionally completed a town hall style group interview with a small contingent of impacted residents to gain further insight into the history and character of the observed nuisance.

On December 9, 2015, HDR traveled to Pleasant Hill to visit and inspect the Dee Zee facility and surrounding areas, measure the vibration of the stamping machinery, and conduct the resident group interview at City Hall. This report summarizes data gathered as a result of those efforts, as well as a discussion and interpretation of the analyzed data and observations to provide an understanding of the noise source and sound propagation medium.

Based upon these data, this report also includes recommendations to remediate the noise and vibration from the Dee Zee facility.

Dee Zee Facility Site Visit Observations

On December 9, 2015, HDR toured the Dee Zee facility and the surrounding area to observe the noise and vibration effects of the machinery, as well as features which would affect the noise and vibration emission and propagation from the facility. Observations recorded during the site visit are presented below by topic.

Building Design & Materials

- The structure has a slab on grade foundation with separate foundations for the stamping presses.
- The building is constructed of steel column beams and joints with light gauge steel wall and relatively thin roof panels comprising the building envelope.
- Thermal insulation (batt with vapor barrier) is present on the interior side of building envelope.
- The building roof was quite flexible and reacted (bounced) noticeably when walking on it.
- An overhead-opening door located in the northeast corner, facing north, was identified by plant personnel as being associated with an increase in noise complaints when it is open.
- No mechanical cooling units (air conditioning) are present. Often on warm days the doors are open to ventilate and cool the interior.

Operations & Process Equipment

- Four stamping presses are located over a continuous trench which is intended to convey waste scrap out of the building from underneath the machines. Several other smaller stamping presses are located on grade with no trench.
- The three largest stamping presses are located on the west end of the trench (near to the conveyer up and out of the trench) and are, in order from east to west:
    - Stamtec, 600 ton press, mounted on fibrous or rubber vibration isolation.
    - Jinan, 600 ton press, mounted on vibration isolation springs.
    - Verson, 500 ton press, mounted on fibrous or rubber vibration isolation.
- The foundations beneath the stamping machines are recessed below the concrete floor slab of the plant and covered with metal plates.
    - The four largest machines are on top of reinforced concrete foundations set on either side of the scrap trench.
    - The foundations for the four largest machines may also be on top of piers driven into the ground, but the documentation isn't clear. If the piers do in fact exist a note on one construction drawing says they were installed at 12-inch diameter and driven only 120-inches into the ground.
    - The remaining foundations are a "bathtub" style set into the slab-on-grade.
    - The metal plates over the Jinan and Stamtec foundations were removed during the site visit to reveal the existing vibration isolation measures for visual inspection.
    - The isolation springs under the Jinan were observed to be overly compressed, without much room for further displacement. It is unclear whether this is the

designed intent of the isolation springs or if they have been over-compressed. This observed condition is further discussed in the Vibration Measurement section, below.

- According to plant personnel, operation of the Jinan stamping machine generates the most complaints from residents. Operation of the Stamtec machine, to a lesser extent, also generates complaints. Operation of either machine was most pronounced (felt and heard) along the east exterior wall of the building. Wall vibration is pronounced, but less so in the north, south and west exterior walls.

Surrounding Property

During resident interviews, a key theme was the observation that noise emanating from the Dee Zee facility became noticeably worse (to the point of becoming irritating) in 2012 at the time an open-air wood shavings/animal bedding stockpile located north of the Dee Zee facility was removed. The property is reported to be vacant since that time.

HDR completed a review of historic aerial photos of the project area from September 2012 and October 2014, respectively shown in Figures 1 and 2 below, and confirmed the existence of the stockpile and relative timing of its removal. Property to the north of the Dee Zee building in the approximate location of the removed stockpile is currently under construction with another large steel building similar to the Dee Zee facility.

Figure 1 – Project Area Vicinity Map, Circa September 2012

Figure 2 – Project Area Vicinity Map, Circa October 2014

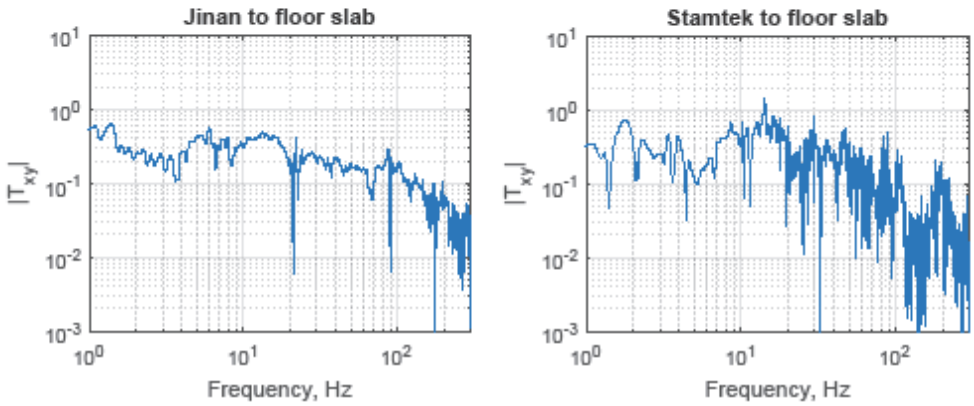
Following completion of the Dee Zee facility visit, HDR toured the Copper Creek neighborhood on Lakeview Drive at around 3:00 PM. At the dead end turnaround directly north of the Dee Zee facility, HDR personnel stopped and listened for observable noise. Construction noise from the area next to the stamping building and road noise were the dominant noise sources. At that time, there was no discernable sound that could be attributed to the impulsive and percussive noise from stamping machines operating at the Dee Zee plant.

Vibration Measurements

HDR measured vibration levels from the Jinan and Stamtec machines, including points on the press, on the footings below the press, on the floor slab beside the press, and on the nearest steel column (floor to ceiling) to each press. Figure 3 presents two graphs showing the transmissibility by frequency – the transfer of vibration from the stamping machine into the floor slab adjacent to each stamping machine.

The $|T_{xy}|$ value of the Y-axis represents the magnitude of the complex transmissibility function between the two measurement signals. A value of 10^0 means the ground motion will be the same magnitude as the stamping machine motion at that frequency (this is "unity" gain where $10^0 = 1$). A value of 10^1 indicates the motion of the ground will be ten times the amplitude of the stamping machine motion at that frequency. Likewise a value of 10^{-1} indicates the motion of the ground will be one-tenth the amplitude of the stamping machine motion, a value of 10^{-2} indicates the motion of the ground will be one-hundredth the amplitude of the stamping machine motion, and so on.

Figure 3 – Vibration transmissibility from Jinan and Stamtec stamping machines into floor slab



One of the purposes of plotting the data this way is to see if a resonant frequency can be identified. Typically the theoretical or ideal transmissibility function is a very recognizable shape, and while measurements rarely follow this shape precisely it often exhibits the most prominent features. This curve typically shows a resonant frequency which is higher than unity, indicating amplification at that frequency (> 10^0). At low frequencies, the transmissibility is typically close to unity (= 10^0). Above the resonant frequency, the transmissibility slopes downward toward smaller and smaller decimal values as the frequency increases.

In evaluating the data in Figure 3, it is difficult to see any resonant frequency in the transmissibility from the Jinan into the floor slab. However, it is possible that the resonance is below 1 Hz, which is outside the lower limit of this measurement method's detection capability. In contrast, the transmissibility from the Stamtec machine to the floor slab is above unity between 10 Hz and 20 Hz, and resonant frequency appears to exist in this case.

HDR also evaluated the signal coherence by frequency for each of these transmissibility functions. The coherence is a measure of how much of the motion at the slab can be attributed to the motion from the machine (irrespective of the magnitude of motion). It is often described as a measurement of signal-to-noise. For both of the measurements shown above, coherence is mediocre at frequencies below 5 Hz. This means the transmissibility values below 5 Hz should be considered to be questionable, although they may not be entirely inaccurate. The coherence for the Stamtec to floor slab measurement is fairly good at the majority of frequencies above 5 Hz, whereas the coherence is quite high—nearly 100%--for the Jinan to floor slab measurement in most frequencies above 5 Hz.

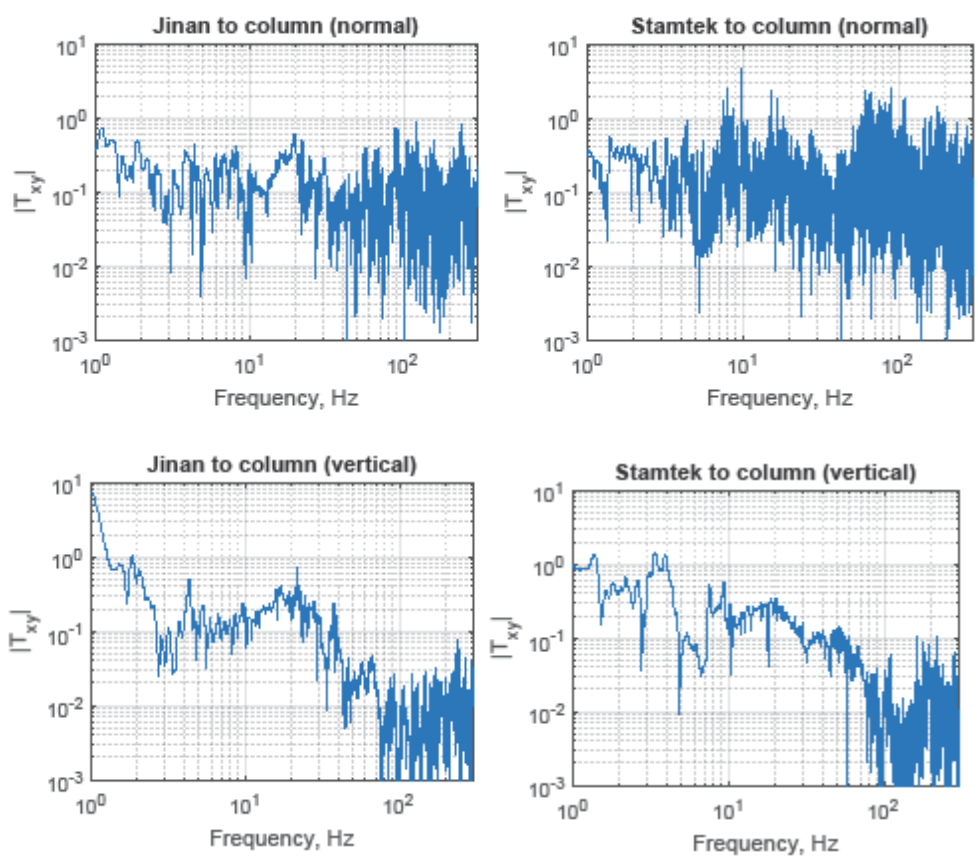
Interpretations of the results of the measured data are as follows:

- Resonance of the vibration isolation from the Stamtec to the floor slab appears to be between 10 Hz and 20 Hz.
- The lack of any apparent resonance from the vibration isolation between the Jinan and the floor slab may support the notion that the vibration isolation springs are not performing as intended, although this is not conclusive evidence.

- The very high coherence from the Jinan to the floor slab may be an indication the springs are providing very little vibration isolation, and allowing the vibration motion to pass into the ground clearly.
- Springs generally are much better at providing isolation and would be expected to show much smaller values than measured under the Jinan, especially at increasing frequencies.

HDR also determined the transfer of vibration from the stamping machines into the nearest column to each machine. Figure 4 presents four graphs showing the transmissibility by frequency from each stamping machine into the nearest column. There are two directions noted for each column. The "normal" direction is measuring the transverse or bending vibration of the column (motion perpendicular to the length of the column, where the vibration causes the column to flex). The "vertical" direction may be measuring in part the compression wave through the column, but more likely represents the vertical motion of the whole column (the up-and-down motion of the ground which causes the column to move as a single rigid body).

Figure 4 – Vibration transmissibility from Jinan and Stamtec stamping machines into normal and vertical vibration movement of nearest column



The coherence of frequencies below 8 Hz is poor for all measurements. The coherence of the vibration from the Jinan into the column is marginal to poor at most frequencies except from 10 to 30 Hz for the normal motion, but is good between 10 and 200 Hz for the vertical motion. Coherence from the Stamtec into the column is poor or mediocre for normal motion at most

frequencies (only a few narrow frequency bands between 10 Hz and 40 Hz show marginally good coherence) and is good only from 10 Hz through 80 Hz for vertical motion.

Interpretations of the results of the measured data include:

- Due to poor coherence, the amplification shown near 1 Hz in the vertical motion of the column may or may not actually be present. In any case, the data suggest there is likely very little reduction of vibration between the machines and the columns in very low frequencies.
- Despite poor coherence in many frequencies in the vibration measurements, it is apparent there is detectable vibration transmissibility from the stamping machines into the normal motion of the columns. This indicates that when the ground moves due to the stamping machine, more energy will go into the flexing motion of the column than into the vertical movement of the column. This flexing motion is likely causing flexing of the roof framing and roof panels.

Resident Perceptions

A survey was distributed to 64 residents of the Copper Creek and surrounding neighborhoods to evaluate times at which the residents were disrupted by sounds from the Dee Zee facility. Locations of the residents who received and responded to the survey along with the sources of police complaints and their position in relation to the Dee Zee facility are shown in Appendix B, Figure 1, Pleasant Hill – Dee Zee Noise Observations.

Following receipt of the resident observation surveys, a small resident group was convened in order to interview residents about their experiences. A summary of the recorded data, observations, and analysis and conclusions drawn from both the surveys and the interview are provided in this section.

Resident Survey Summary

Sixty-four surveys were distributed to residents and six (6) completed surveys were returned. Residents were asked to report the times when they observed noise which they would attribute to Dee Zee facility stamping operations, and how disruptive the observed noise was. A copy of the blank resident log form distributed to residents is provided in Appendix A.

The table below provides a summary of the resident observation data by showing the dates where at least one respondent reported the noise from Dee Zee was at least somewhat disruptive (3 or higher on a subjective self-reporting annoyance scale of 5). The times shown as "Incident Time" represent the range of times when the respondents first observed the noise, not the duration of the noise.

Table 1 – Resident Observations Summary Table

Incident Date	Incident Time	Number Noticed (0-5)	Number Annoyed (3-5)
October 23	5:30 PM	1 (17%)	1 (17%)
October 30	6:00 PM – 9:30 PM	3 (50%)	2 (33%)
November 2	6:30 AM – 7:30 AM	4 (67%)	2 (33%)
November 2	5:15 PM	1 (17%)	1 (17%)
November 3	3:30 PM – 7:00 PM	3 (50%)	1 (17%)
November 9	4:00 AM – 4:30 AM	4 (67%)	3 (50%)
November 9	11:00 AM	1 (17%)	1 (17%)
November 9	6:00 PM	1 (17%)	1 (17%)
November 10	2:00 AM – 9:30 PM	4 (67%)	3 (50%)
November 10	12:00 PM	1 (17%)	1 (17%)

Incident Date	Incident Time	Number Noticed (0-5)	Number Annoyed (3-5)
November 10	4:30 PM	1 (17%)	1 (17%)
November 13	11:00 PM	1 (17%)	1 (17%)

Resident Interview Summary

A group of Copper Creek residents was gathered for a town hall style group interview with City and HDR personnel. The following list of resident feedback represents key takeaways or recurring themes from our discussion.

- Several of the comments concerned a changed condition. Before 2012 a large sawdust / wood shavings pile was on the property just north of the Dee Zee facility. The pile has since been removed and the noise has since become significantly louder.
- Noise is apparent throughout each house, and not just near a window.
- The noise is constant and sounds similar to a bass drum or impulsive/percussive sounds from a loud car sub woofer.
- Rush hour traffic is typically not heard within the houses.
- Noise from Dee Zee, and the associated concussive pressure feeling, is most noticeable during summer months.
- The hours between 9 pm and 4 am appear to be the most bothersome.
- Several comments indicate the noise is more prominent when the door (northeast side overhead door) is open.
- Residences reporting noise problems all live up hill from the Dee Zee facility (to the North and West).

Neighborhood Complaints

HDR combined the observed nuisances from the resident surveys with police reports showing complaints about the noise from the Dee Zee facility. These were compared against weather data for those days where a complaint was registered.

Table 2 – Table of resident complaints from police reports and from resident surveys.

Complaint Date	Complaint Time	Temp. (°F)	Humidity	Bar. Pressure (in)	Wind Direction	Wind Speed (mph)	Conditions
22-Jul	6:00 PM - 11:00 PM	75-64	65%-94%	29.9	East	5.8-Calm	Clear
25-Jul	11:00 PM	77	94%	29.9	Calm	Calm	Overcast
27-Jul	9:30 PM - 11:00 PM	73-72	88%-94%	29.9	SE-ESE	5.8-3.5	Clear to Scattered Clouds
4-Aug	4:00 PM - 11:00 PM	77-70	61%-88%	-	ESE- East	4.6-3.5	Clear to Overcast

15-Aug	7:00 AM	64	100%	30.2	Calm	Calm	Clear
27-Aug	5:00 AM	53	100%	30.1	Calm	Calm	Clear
1-Sep	11:00 PM	72	94%	30.0	SSE	4.6	Clear
16-Sep	6:30 AM	66	78%	30.0	South	11.5	Clear
28-Sep	4:00 AM	59	100%	29.9	Calm	Calm	Clear
25-Sep	6:00 PM	77	50%	30.2	ENE	11.5	Clear
21-Sep	4:51 AM	53	94%	30.0	SSE	4.6	Clear
23-Oct	5:30 PM	63	100%	29.8	SSE	6.9	Overcast
30-Oct	6:00 PM – 9:30 PM	50-48	71%-76%	29.9	SSE- South	5.8-8.1	Clear to Overcast
2-Nov	6:30 AM – 7:30 AM	54-55	77%-72%	29.8	SSW-South	8.1, gusts 13.8	Clear
2-Nov	5:15 PM	70	38%	29.9	SSW	9.2	Clear
3-Nov	3:30 PM – 7:00 PM	72-63	57%-77%	29.9	SSE	11.5-15.0, gusts 23.0	Clear
9-Nov	4:00 AM – 6:00 PM	34-54	81%-41%	30.2-30.1	SSE-SW	4.6-9.2	Clear
10-Nov	2:00 AM – 9:30 PM	30-63	87%-37%	30.1-29.8	South- ESE	Calm-15.0	Clear to Mostly Cloudy
13-Nov	11:00 PM	34	75%	30.2	Calm	Calm	Clear

No precipitation events occurred during the periods identified above. In general, the weather observations occurring during periods of complaint exhibit winds which are mostly calm or low speed and which are predominantly in a SSE/SE/ESE direction (although not exclusively). Therefore, during the majority of complaint periods many of the residents would be located downwind of the plant and the conditions would be favorable to provide a relatively smooth wind gradient.

The sound which would normally be directed up into the atmosphere during these conditions will be diffracted through a downwind gradient towards the ground. Furthermore, low wind speeds do not afford an opportunity for atmospheric turbulence to diffuse or scatter the sound. These are favorable conditions for carrying sound from the facility and carrying it into the neighborhood.

Method of Noise Propagation

HDR has evaluated the information gathered from Dee Zee, resident observations and interviews, on-site inspection of the noise sources and the circumstances of the sound and vibration propagation, and the vibration measurement results. These data indicate that despite the previous report identifying groundborne vibration through mines as the transmission path, the noise is more likely transmitted from the source to the residences as airborne sound. Groundborne vibration is unlikely to be the source of the noise nuisance based upon the following evidence:

- Even with efficient groundborne vibration propagation media, vibration typically only travels a few hundred feet through the ground before dropping to undetectable levels.
- Reviewing records of the prevailing geology shows deep bedrock and limited presence of near-surface geologic formations which could act as efficient propagation media.
- Terrain between Dee Zee and the Copper Creek neighborhood includes a drop into Little Fourmile Creek and large rise up the opposite bank to the neighborhood; this topographic relief would inhibit groundborne vibration propagation.

Airborne noise is the likely transmission path for the plant noise to the neighborhoods based upon the following evidence:

- The intermittent nature of nuisance complaints is consistent with sound propagating through the atmosphere.
- Noise complaints were described by residents as mainly occurring during the evening or early morning hours. This is consistent with evening and overnight occurrences of temperature inversions, which typically increase noise levels at ground elevation.
- Reported noise complaints were often during times when the prevailing wind was low to calm, and when the noise source was upwind from the residences.
- The apparent increase in noise during evening/night times reported by residents is likely amplified due to a reduction in the masking sound (i.e. road traffic and other outdoor ambient noise) at those times, making the Dee Zee noise sound relatively louder or clearer.
- The apparent increase in sound from Dee Zee began about the same time the wood shavings stockpile (located north of the Dee Zee facility) was removed. The acoustically absorptive surface of the large wood shavings pile can, and very likely did, measurably attenuate sound pressure levels.

Based on information collected during the site visit, HDR believes the high sound levels emitting from Dee Zee are due to structural vibration of the building itself. Vibration from the stamping machines passes from the slab foundation into the steel beams. The vibration induced-flexing and movement of the beams causes flexing vibration in large sections of unsupported thin-gauge metal sheeting on the building roof. In addition, the impulsive sound pressure wave from the stamping machine strikes the thin-gauge metal sheeting on the building roof and also induces it to vibrate. The large vibrating surface area of the roof then induces airborne sound waves into the outside environment.

The analogy to this sound generation method is a loudspeaker. Loudspeakers are designed to electrically drive vibration through a speaker cone or film, which in turn induces the surrounding air to vibrate as audible sound. Low-frequency speakers (especially bass woofers) are designed with a port opening to further amplify the sound (increasing the efficiency of the speaker). In the case of the Dee Zee facility, the light gauge sheet metal building envelope is analogous to a speaker cone or film vibrating and inducing sound in the air, and open building doors (specifically on the north side of the building) are analogous to a speaker port opening.

It is unclear what impact construction of the new building north of the Dee Zee facility will have on the observed noise nuisance. As we do not know the progress of the construction, or the height and expanse of the new building in relation to the existing building, or the materials of construction, we might only assume that it will have some effect. It will offer some shielding effect, but also will provide a reflecting surface and channel between the two buildings. The net effect could be positive (i.e. reduced nuisance), no effect at all, or simply to channel the nuisance to an alternate set of property owners.

Recommend Actions

Based on evaluation of data collected during this project, we offer the following possible solutions to the observed noise nuisance from the Dee Zee facility, listed in order of preference of implementation:

1. Bring out the original equipment manufacturers to view the isolation springs under the Jinan unit to evaluate whether the springs are performing as they were designed. Without additional information from the manufacturer we cannot say for certain that the spring absorbers are not working properly, however based on visual inspection the springs appear to be in a collapsed state as opposed to being “springy”. The measurement data do not refute this observation. Both the Jinan and Stamtec OEMs should be brought in to view and comment on the operation.
2. Add climate control or additional ventilation to the Dee Zee facility for use during the summer months, so that doors do not need to be opened to cool the building. This will eliminate the port-effect of the loudspeaker analogy, and reduce the complaints closer to pre-2012 numbers.
3. Enclose the two largest stamping machines in a freestanding acoustical enclosure inside the plant. This will greatly reduce the effect of the impact sound from the presses traveling through the air and exciting the roof panels, as well as much of the port effect from open doors. While it would not impact vibration traveling through the ground and into the roof panels via the columns, the overall reduction could reduce the overall noise produced from these activities to acceptable levels.
4. Increase the acoustical isolation of the building envelope – especially the roof. This would require adding material to the ceiling (the underside of the roof) such as additional acoustical insulation and a perforated metal panel facing or a quilted acoustical barrier.
5. Install a vegetated earthen berm north of the Dee Zee facility to act as a large expanse of sound-absorbing surface. This would make a measurable reduction in sound propagation due to the grazing-angle and the berm material sound absorption. Due to numerous unknown variables related to the impending building construction in the same location, however, it is possible this option would not be viable without a disruption to planned Dee Zee business operations.

The following actions were considered, but are not recommended at this time:

1. It may be possible to design more effective vibration isolation under the stamping equipment. However, not only is this likely to be costly, it would also take the equipment out of commission for a period of time. This option is therefore not part of HDR’s recommendations at this time.
2. Another method of reducing vibration could be achieved with resonant mass dampers. This reduces the vibration of one object by adding another mass to it which can vibrate freely – an engineering trick which is often counterintuitive to many. These dampers could conceivably be added to the building structure or to the stamping machines themselves. However, this approach would require a much more extensive measurement program and detailed modeling in order to achieve some reduction, and

the value of the reduction achievable with this method is uncertain. Therefore, this approach is not recommended.

3. Stamping vibrations from machine foundations are being transferred to certain building columns and thus to the rest of the structure. It would seem that mechanically decoupling the roof from the ground vibrations could greatly reduce much of the noise generated from the plant. This could be in the form of lifting the roof off the columns to install resilient material, or lifting the columns off the ground to install resilient pads. As suggested by the impractical description, this is only a speculative notion for discussion's sake and is not recommended.

Sequence of Implementation

Due to the complexity of sound generation mechanisms from the plant and its building, it is difficult to predict the exact reductions achievable with any of these methods. Based on experience and expert judgment, HDR highly recommends first enquiring with the original equipment manufacturers for the stamping equipment. Following that step, HDR recommends adding climate control to the building to allow the doors to remain closed even in the warm summer months. As a subsequent step, if observed noise from the facility remains at unacceptable levels, HDR then recommends either creating an acoustical enclosure around the two largest stamping machines or adding isolation to the roof as described above.

The options recommended by HDR are presented in Table 3, along with a summary of the anticipated costs, in order of recommended implementation sequence. The recommendations are also discussed in additional detail below.

Table 3 – Summary of Recommendations

Recommendation	Approximate Cost	Comments
Equipment Manufacturer Evaluation	TBD	The manufacturer may or may not charge for this visit.
Plant Ventilation	$110,000	Cost may be less depending upon the current building ventilation capacity.
Acoustical Enclosure	$90,000	Cost may vary depending upon the structural frame, openings, and lighting/ventilation.
Roof Isolation	$480,000	Price shown is for the most obvious and effective material; however there are many other less expensive materials available, depending upon the design.
Earthen Berm Construction	$150,000	Recommend delaying this option for further evaluation once construction of the new Dee Zee metal building is complete.

Equipment Manufacturer Evaluation
There is not additional detail which needs to be discussed on this option, however HDR emphasizes this step is a high priority. The qualitative and quantitative observations of the springs under the Jinan do not provide sufficient evidence that they provide adequate vibration isolation. The manufacturer needs to provide an explanation of exactly what the springs were designed to achieve, whether the springs have achieved their design intent, and if not, provide options to remedy.

Plant Ventilation Approach
HDR suggests the most reasonable approach to provide sufficient cooling during the summer months so doors do not need to be opened is to improve the ventilation of the space. This design should take into account the current ventilation design of the plant. However, in lieu of that level of specific information, HDR will tentatively recommend ventilating the space at 3 air changes per hour. Given the size of the building, this would require approximately 100,000 cubic feet per minute of air handling capacity.

This ventilation could be accomplished with five wall-mounted exhaust fans. The fans would benefit from ductwork to decrease the noise to the outside, and the building would also require approximately 200 square feet of louver intake and motorized intake dampers. The cost for this solution could range from $95,000 to $110,000. This cost could easily change depending upon the current ventilation capacity.

Acoustical Enclosure Approach
The acoustical enclosure could be quilted acoustical barriers fastened on five sides (top and four sides) from a large framed structure to completely cover the Jinan and Stamtec machines. The quilted material is typically estimated at $12 per square foot, and estimating to include a structural frame to hang the quilted material results in approximately $15 for both the material and frame. The perimeter of an enclosure surrounding the machines is approximately 200 feet. An enclosure 18 feet high should cover the machines, and the frame and material would cost approximately $54,000 for the four walls. The enclosure top in this scenario is about 2,300 square feet and is estimated to cost a minimum of $34,500. Additional cost may be required for the selected structural support required to hold the quilted material horizontally. The quilted barrier material would cost approximately $71,000 without the frame or other considerations.

The enclosure will require some openings to allow the raw material feed into the machines and doors to allow the bins of finished products to be moved out. These considerations would also increase the cost. In addition, the enclosure will benefit from its own ventilation and lighting, further increasing the cost. All told, the cost for a freestanding acoustic enclosure as described would start in the range of $90,000 for the low end.

Roof Isolation Approach
One of the simplest approaches to increasing the roof isolation is to fasten the same quilted barrier material described for use in the acoustic isolation enclosure to the underside of the roof structure. To cover the east half of the building would require approximately 40,000 square feet, for a total material cost of approximately $480,000.

Alternative materials could reduce the cost. Such materials could come from a metal building manufacturer, who may have options designed to work specifically for their buildings. There are also numerous third party manufacturers of acoustical isolation materials. A final alternative is to use standard building materials to accomplish improved vibration dampening. These can range from additional insulated metal panels on the interior to rigid glass fiber panels and gypsum board fastened to the underside of the roof structure.

The roof isolation would need to cover much of the ceiling, but it may be possible to achieve satisfactory noise reductions without covering the entire ceiling. One option may be to implement the roof isolation in an incremental manner, adding isolation to a large portion of the roof around the stamping machines, evaluating the results, and then adding additional isolation to the rest of the roof until satisfactory results are achieved.

The exact selection of materials will need to account for the structural capacity of the building roof, as well as any potential building codes for the jurisdiction. These considerations were not evaluated as part of the scope of work for this project.

Earthen Dampening Berm Approach

As the final recommended alternative, a vegetated earthen berm could be constructed north and northwest of the Dee Zee facility in the general location of the previous wood shavings stockpile shown in Figure 1, or potentially closure to Little Fourmile Creek. Based on the success of the previous stockpile in deflecting and absorbing sound, we recommend constructing the berm to a height of 15 feet and length of 340 feet, which is approximately equal to what was in place previously. A berm of this size would require 12,300 cubic yards of offsite soils and approximately one (1) acre of seeding and erosion controls. Unless the City is able to utilize connections to large earthwork construction projects with available excess soils, this option would require a capital investment of approximately $150,000 based on current local construction costs.

As discussed previously, construction of the earthen dampening berm is entirely contingent on details of the new Dee Zee metal building being constructed in that same location. For this reason, we currently recommend putting this option on hold until a future date. Once the building is constructed and its impact on the observed nuisance to Copper Creek residents can be evaluated, the earthen berm construction option should be reevaluated.

Appendix A

Noise Nuisance Observations Blank Log Form

This page intentionally left blank.

Noise Nuisance Observation Log

Please return this completed Observation Log to your City of Pleasant Hill contact by no later than Friday November 20, 2015.

Name _____

Address _____

Please fill in the log below when you observe noise/vibration from the stamping plant. Please rate how noticeable and annoying your observation was (1 = just noticeable, 5 = it interfered with activity.)

Date	Time (start/stop)	Observations	How Noticable? (rate 1-5)	How Annoying? (rate 1-5)	What were you doing at that time?

C:\Users\mclassen\Desktop\Projects\City of Pleasant Hill\Pleasant Hill observation log

This page intentionally left blank.

Appendix B

Noise Nuisance Observation Location Map

This page intentionally left blank.

HDR

PLEASANT HILL - DEE ZEE
NOISE OBSERVATIONS

(FIGURE 1)

PATH: \\MSPE-GIS-FILE\GISPROJ\134_OMA\PLEASANTHILL\268603\7.2_WORK_IN_PROGRESS\MAP_DOCS\DRAFT\PLEASANTHILL_OBSERVATION_LOCATIONS_11X17L.MXD - USER: JWALTER - DATE: 2/4/2016