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Reduction of Shelling-Plant Noise Caused By Impingement of Peanuts

By

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ABSTRACT

Measurements in numerous peanut shelling plants revealed that the striking of metal surfaces by peanut pods and kernels was a major source of noise. Noise level was affected by thickness of metal and kinetic energy of peanuts (height of fall and flow rate of peanuts). Results from controlled tests showed that plant noise could be substantially reduced by use of modified handling techniques, by use of various damping treatments, and/or by enclosure of the noise sources.

Keywords: peanuts, noise-levels, damping-treatments noise-reduction, impingement-noise, shelling plants, noise-sources.

The normal process of shelling peanuts is very involved and requires that the material (pods, kernels and shells) be moved or transported from one machine to another many times. To provide for the movement, peanut shelling plants have large numbers of elevators, conveyors, chutes, hoppers, pipes, bins, screens, and other devices on which the peanut particles flow and strike. Most of the equipment is constructed of sheet metal and as the peanuts strike the metal, noise is emitted from both surfaces of the sheet metal. Preliminary measurements indicated that impingement noise was a significant portion of the overall noise level in shelling plants. The objective of this report is to provide information that can be used in reducing the overall noise level in peanut shelling plants.

Materials and Methods

Measurements of sound pressure level (SPL) were made in a number of commercial shelling plants, and in the National Peanut Research Laboratory (NPRL) pilot shelling plant. Survey-type measurements were made in aisles and at worker locations, and near-field (close to the source) measurements were made on all types of processing and handling equipment. All measurements were made with a General Radio Model 1933 precision sound-level meter. Generally, values were recorded for both the A-scale and for 10 individual octave bands having center-frequencies of 31.5 to 16,000 Hz. The A scale combines the values of all frequencies, weighing more heavily those values to which the human ear is most sensitive.

Guided by the data obtained from the plants, methods for reducing the noise were investigated. The noise reduction methods fell into three broad categories — modification of handling techniques, enclosure of the noise sources, and treatments of metal surfaces.

Evaluations of modified handling techniques were conducted at the NPRL pilot shelling plant, and at commercial plants. Modifications were devised which prevented particles from attaining excessive kinetic energy, and prevented particle energy from reaching metal surfaces. Descriptions of the test setups are incorporated in the Results section to enable the discussion of the

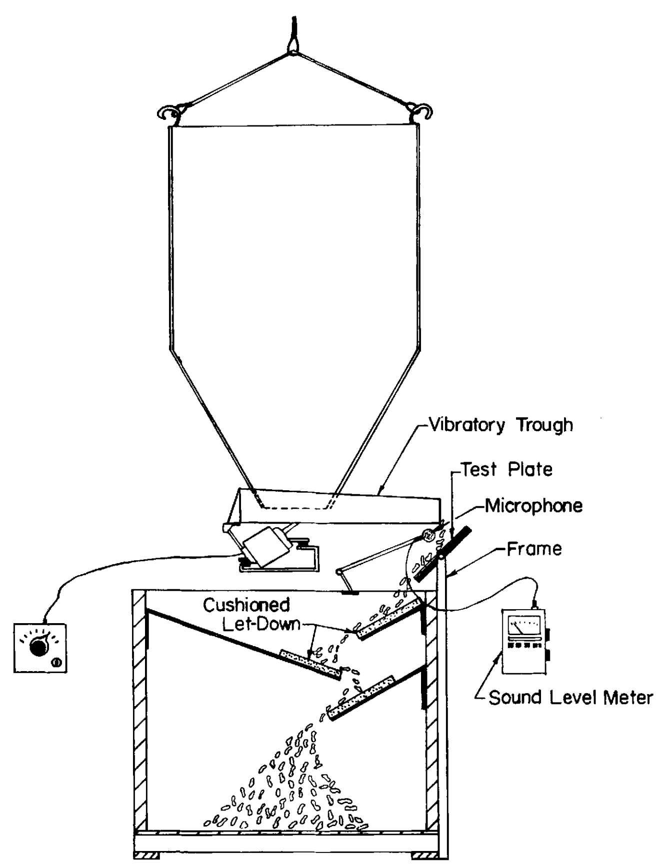

Fig. 1. Apparatus evaluating the effect of variables and damping treatments on sound pressure level.

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[2]Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the U.S. Department of Agriculture and does not imply its approval to the exclusion of other products that may be suitable.

theory, advantages, variations, and limitations of the different methods.

Tests of variables affecting impingement noise and of treatments of the metal to reduce the noise were evaluated with a special test apparatus, shown in Figure 1. This setup allowed variations of material flow rate, material drop height, material composition, and microphone locations, while peanuts were being dropped on flat metal plates which were clamped in a test fixture. Test results determined selection of one of the metal treatments for further evaluation in the pilot shelling plant.

An enclosure system was also evaluated in the pilot shelling plant. Measurements of SPL were first made near a bare metal pipe in which peanut kernels were flowing. The pipe was then enclosed with fiber glass material, and measurements were repeated.

the contours can be used as the A value, for OSHA purposes, although it may differ from the actual A value. This shows the relative importance of the individual frequency band values. Note that processing causes large increases in the SPL at 2000 and 4000 Hz, the frequencies most heavily weighted in determining A values.

Also note in Figure 2, and succeeding figures, that lower equivalent A values result from the OSHA curves than from the metered value in many peanut handling situations. This demonstrates an advantage of measuring SPL's at individual frequency bands, if the instrumentation is available.

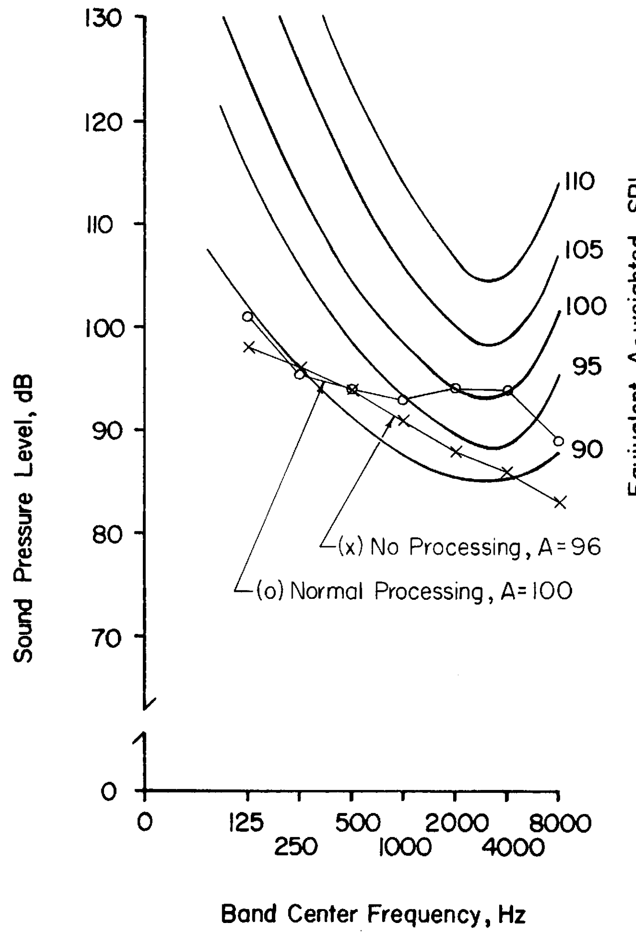

Fig. 2. The effect of peanut processing on sound pressure level in a commercial shelling plant, all equipment operating.

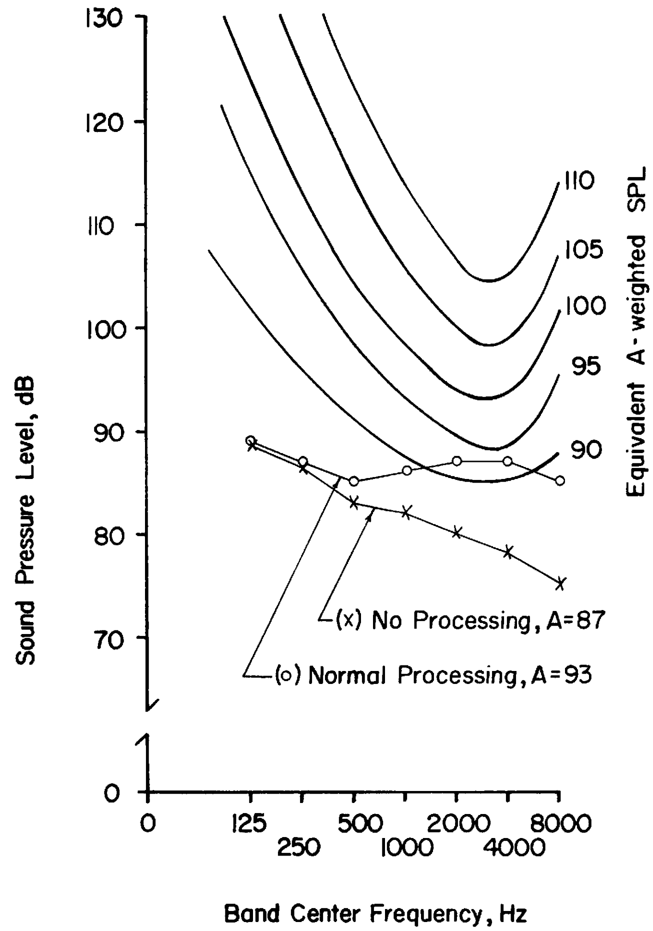

Fig. 3. The effect of peanut processing on sound pressure level in pilot shelling plant, all equipment operating.

Results

Noise Survey

Figures 2 and 3 show representative noise levels of shelling plants with all equipment operating, both with and without peanuts being processed. These figures, and those following, also show a family of curves prescribed by the Occupational Safety and Health Administration (OSHA) (2) for determining an equivalent A-weighted SPL. The highest penetration of any value of the individual bands into

Near-field measurements made in several shelling plants indicated that the sources of loudest sound were metal surfaces such as found on downspouts, chutes, elevator hoppers, and troughs, which diverted and channeled peanuts. Generally, the noise was emitted from both sides of the metal surface being struck by the particles. Downspouts seemed to act as megaphones in some instances, magnifying the effect of the noise created down inside the pipe. Some typical SPL's are shown in Figures 4 and 5 at the opening of a downspout and underneath a sheller chute.

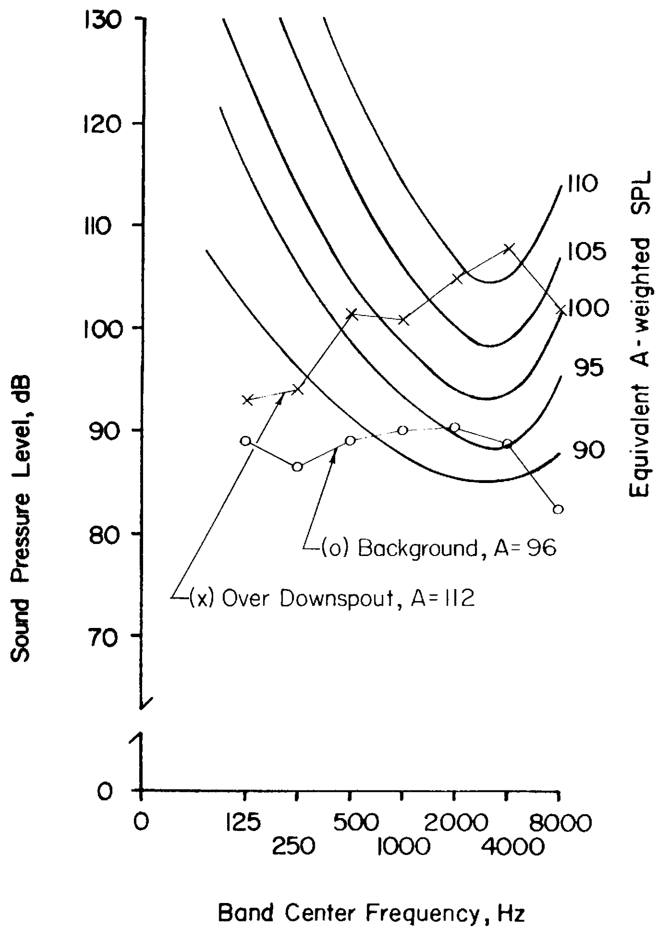

Fig. 4. Sound pressure level at opening of downspout handling shelled peanuts.

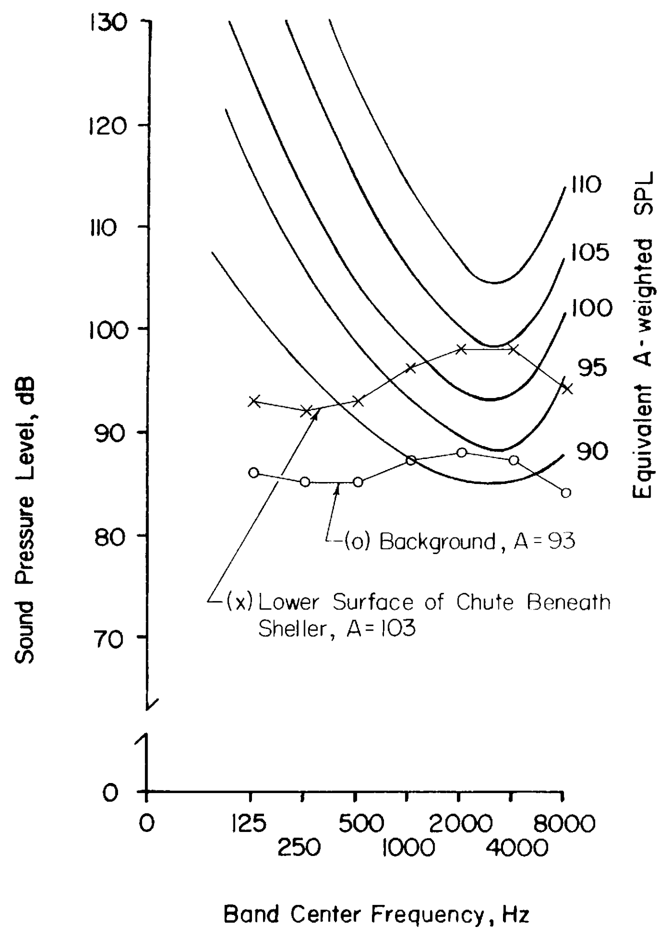

Fig. 5. Sound pressure level at lower surface of chute beneath sheller.

Effect of Variables

The noise emitted from the metal surfaces is the result of kinetic energy of the particles which is transferred to the metal and converted into sound energy. As the drop height of the falling peanuts is increased, particle velocity, and therefore particle energy, is increased. This effect of drop height on noise emitted from a flat plate is shown in Figure 6.

The effects on SPL of metal thickness and peanut flow rate are shown in Figures 7 and 8. As expected, the SPL increased for thinner metals and higher flow rates. Additional tests (not illustrated) showed that noise produced by unshelled peanuts dropping on the flat plate was about equal to that of the whole kernels; however, split kernels producted slightly less noise.

Handling Techniques

Noise caused by the kinetic energy of peanut particles impinging on surfaces can be reduced by two basic handling modifications — preventing the particles from attaining excessve kinetic energy or, if the peanuts acquire the energy, preventing the energy from reaching the metal surfaces.

The most obvious method of reducing the kinetic energy of the particles is to reduce the height of fall. All peanut shelling plants depend on gravity feed throughout the processing, and the amout of fall on most handling setups is established as the minimum which will meet the other criteria, i.e., the minimum vertical fall that must exist to convey peanuts a given horizontal distance by gravity. By modification of the handling process, the amount of fall can be reduced in some instances. Assume that peanuts leave a processing operation at elevation h_1 and must be conveyed to another hopper of height h_2, a given horizontal distance away. In Figure 9, the peanuts are elevated to height h_3 and then allowed to fall to height h_2 attaining energy approximately in proportion to the difference in height h_3-h_2. An alternate to this method is shown in Figure 10. Here, the peanuts are elevated only to height h_2, then transferred by a horizontal conveyor and allowed to fall more gently into the hopper. Observe that with the situation shown in Figure 9, and "easy letdown" device within the hopper is of little value because of the great velocity attained by the particles falling from h_3 to h_2. We know of no effective device for gently slowing particles once they have attained high velocities.

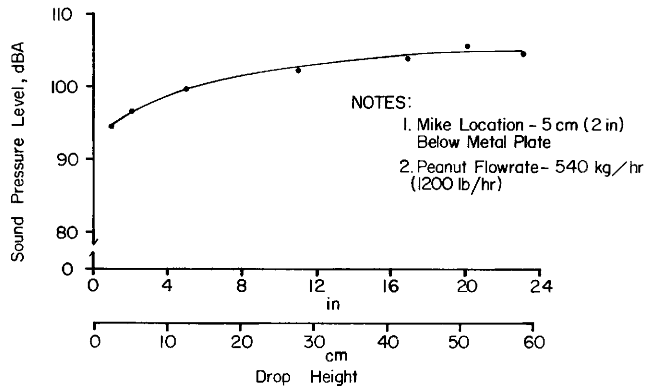

Fig. 6. The effect of peanut drop height on sound pressure level.

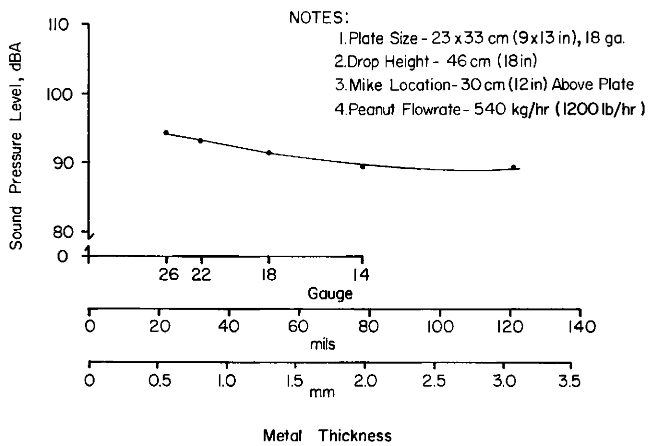

Fig. 7. The effect of metal thickness on sound pressure level.

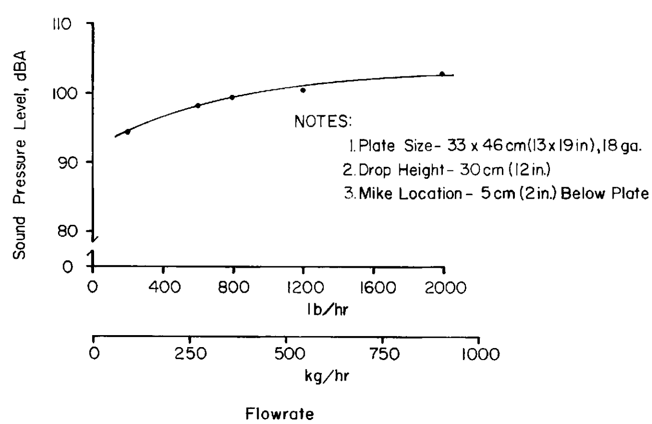

Fig. 8. The effect of peanut flow rate on sound pressure level.

Conveyors are available in which the buckets move both in the horizontal and vertical directions, achieving the desired effect shown in Figure 10.

Another method of reducing free-fall velocity is illustrated in Figure 11. Here the sensor for an electrical control system is placed in the pipe at height h_3 to maintain the level of peanuts at this height by controlling the mechanism at h_2. The mechanism can be a small vibrating trough, which

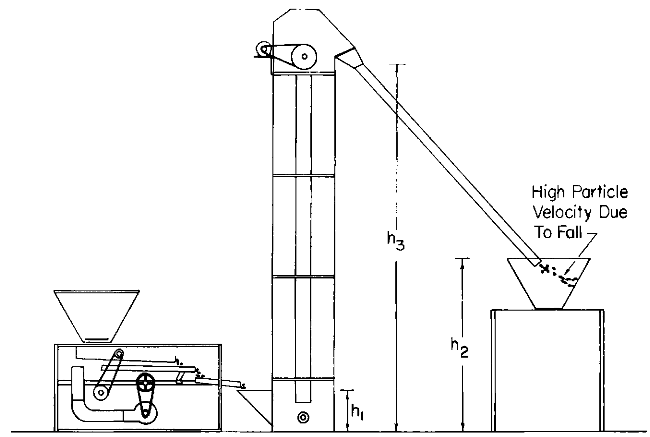

Fig. 9. Illustration of horizontal conveying which allows excessive peanut velocity due to gravitational acceleration.

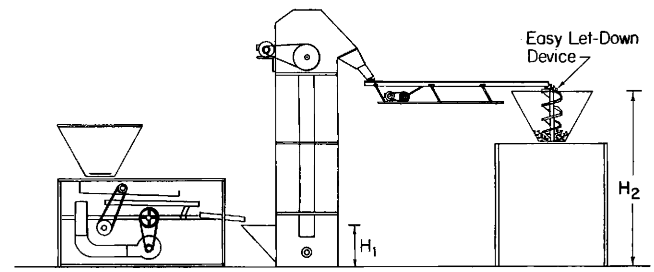

Fig. 10. Illustration of horizontal conveying which avoids excessive peanut velocity.

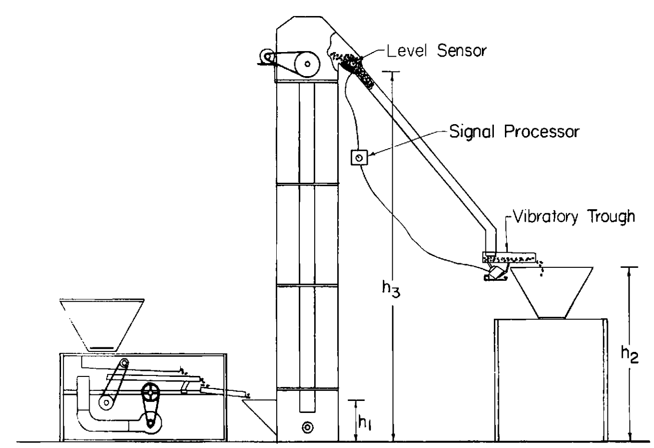

Fig. 11. Illustration of horizontal conveying which avoids excessive peanut velocity.

can be installed with a downward slope for high capacity. The performance of this type of system installed at the NPRL is shown in Figure 12. Objectionable noise was essentially eliminated, and operation of the system was satisfatory. A variable position gate or conveyor might also be used as the mechanism at h_2.

The other modified handling technique — preventing the particle energy from reaching the metal surface — can be implemented by providing a

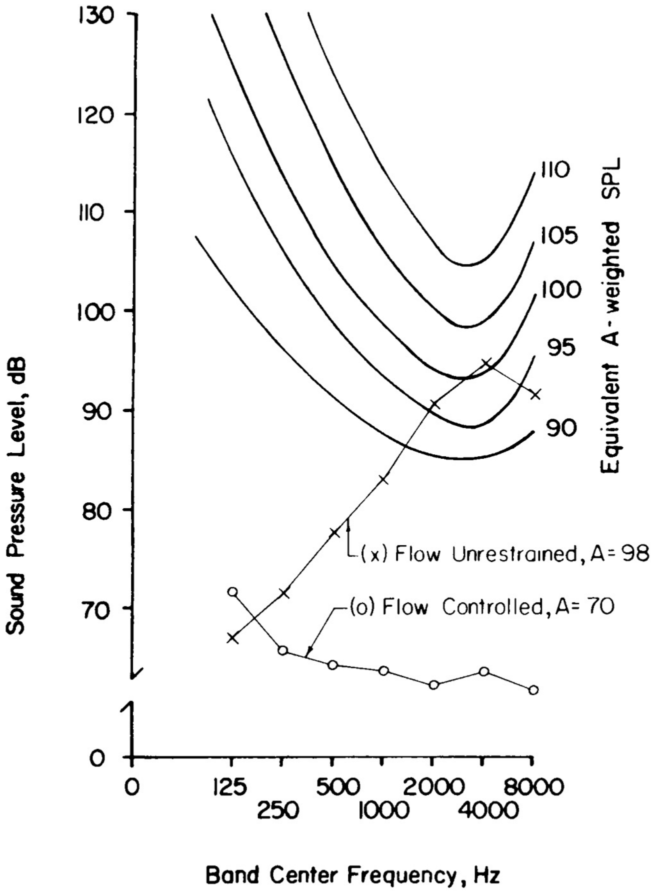

Fig. 12. The effect of flow control device on sound emitted from peanut transfer pipe.

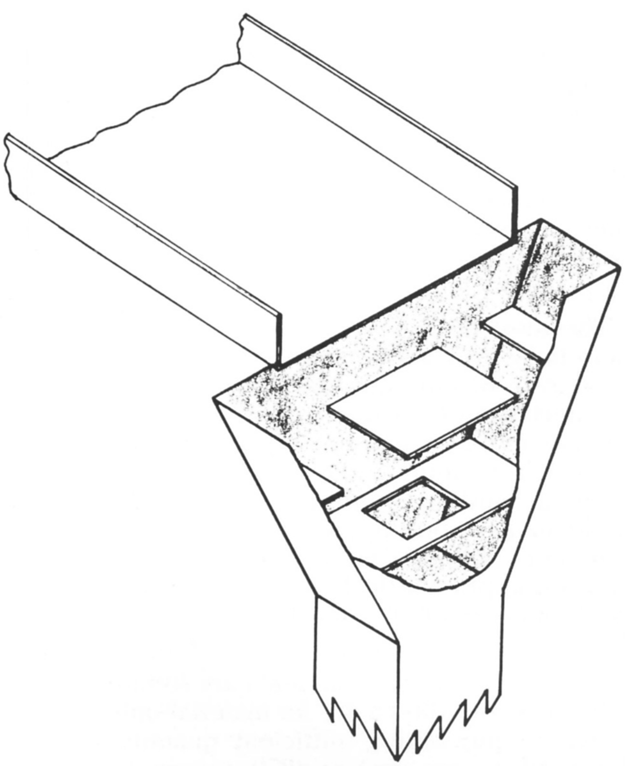

Fig. 13. Baffles installed in a chute to entrap peanuts.

Fig. 14. Photograph of chute with baffles installed to entrap peanuts.

cushion of peanuts at points where a stream of peanuts strikes. This effect can be attained in hoppers by ensuring that flowing peanuts are directd to the center, where a buildup of peanuts can result, rather than toward a metal surface. A method which can be used in chutes, where peanuts do not normally accumulate, is illustrated in Figure 13, and shown in use in the photograph of Figure 14. Here baffles are employed to entrap peanuts, preventing the falling peanuts from contacting the metal surfaces of the chute. The performance of this method in a commercial plant is illustrated in Figure 15. The baffles are placed such that sound has no direct path up from the pipe below. This method is most suitable in accessible locations which can be cleaned regularly of accumulated peanuts.

In addition to noise reduction, the modified handling techniques described also reduce handling damage, and this benefit would perhaps pay the installation costs with long-term savings from handling damage. Slay (3) found that damage to shelled peanuts as measured by split kernels, oil stock, and bald kernels, and to inshell peanuts as measured by split kernels, cracked or broken pods, foreign material, and loose shelled kernels, increased in proportion to drop height. Also damage was considerably less for peanuts falling on other

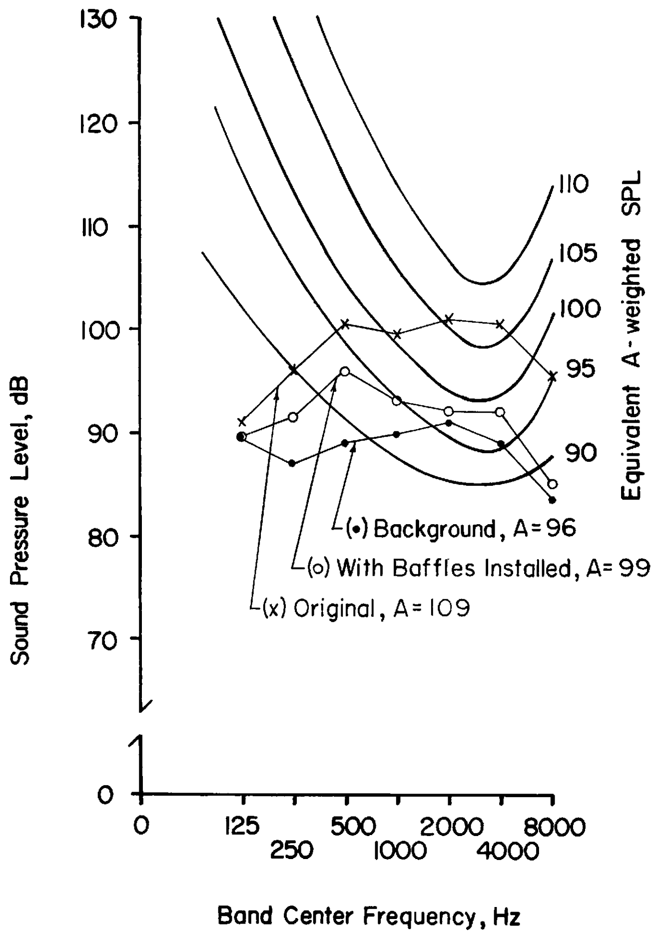

Fig. 15. The effect of entrapment baffles on sound pressure level above chute.

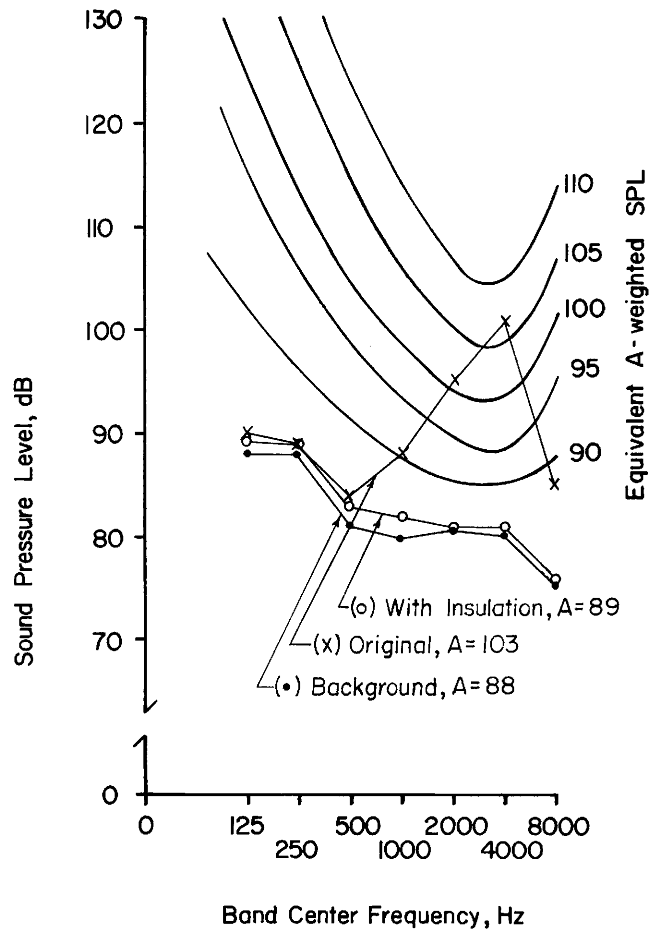

Fig. 16. Comparison of near-field sound pressure level of pipes before and after treatment with insulation.

peanuts rather than on wood, steel, or concrete.

Enclosure System

For situations in which kinetic energy of the peanuts cannot be reduced or diverted, two additional alternatives are available — enclose the source of noise, or prevent the peanut energy from being converted into sound energy. Treatments to reduce noise from pneumatic ducts which convey peanut hulls are described in depth in (4). Fiber glass wrapping was recommended as most effective, considering cost and performance. This treatment is also effective for reduction of noise caused by peanut particles impinging on metal surfaces, provided that the noise source can be contained by the fiber glass treatment. Pipes conveying peanuts would be adaptable, whereas, an open hopper or chute would not lend itself to treatment. This treatment was applied to pipes in the pilot shelling plant in which peanut kernels were flowing from a grader to a bin. As seen in Figure 16, this treatment was quite effective. The background sound pressure level shown is that of all equipment other than the subject pipes.

Treatments of Metal Surfaces

The final alternative for noise control of the impinging peanuts involves treatment of the metal being struck by the particles. Treatments applied to either the upper (impacted) or lower surface can be effective.; A number of different types of treatments were evaluated for effectiveness, economy, and convenience in reducing noise on standard flat plates. A discussion follows on the results of these evaluations.

The most obvious treatment to reduce impingement noise is a layer of relatively soft, resilient material over the impingement surface. However, such a material must be relatively abrasion-resistant to prevent rapid wear from the continuous impingement of the peanuts, and it must meet FDA standards for food handling equipment. One such material, food-conveyor belting, was evaluated for noise attenuation. All other treatments were some form of damping applied to the lower surface of the impingement metal — out of contact with product.

The results of the treatments are summarized in Table 1. Costs shown are for material only and are based on purchasing sufficient quantity to treat about 40 square meters (370 square feet). The damping effect at the individual frequency bands is

Table 1. Comparison of damping treatment for flat metal plates.[1]

	Treatment description	Additional thickness, mm	(in.)	Coverage (pct)	Additional weight, 2/ kgm/m^2	(lb/ft^2)	Attenuation effect, dBA	Approximate cost, \$/m^2	(\$/ft^2)
1.	Three-ply food-conveyor belting, glued to upper surface	3.61	(0.142)	85	3.95	(0.81)	11	32.30	(3.00)
2.	Vibrodamper (Korfund Dynamics Corp.), troweled on lower surface, 1.1 kgm/m^2 (0.22 lb/ft^2) wet weight	.51	(.020)	85	.68	(.14)	5.5	1.30	(0.12)
3.	Same material as 2 above, 2.5 kgm/m^2 (0.51 lb/ft^2) wet weight	1.14	(.045)	85	1.56	(.32)	7.2	2.90	(.27)
4.	Soundown 727 (Safety Aids, Inc.), on lower surface 2.4 kgm/m^2 (0.50 lb/ft^2) wet weight	1.16	(.046)	85	1.51	(.31)	3.8	1.20	(.11)
5.	Self-adhering flexible damping sheet applied to lower surface	1.27	(.050)	71	1.90	(.39)	8	18.30	(1.70)
6.	Magnetized rubber damping sheet, applied to lower surface	1.52	(.060)	21	1.12	(.23)	4	30.40	(2.80)
7.	Same material as 6 above	1.52	(.060)	41	2.20	(.45)	6	60.90	(5.70)
8.	Same material as 6 above	1.52	(0.060)	83	4.39	(0.90)	10	125.00	(11.60)
9.	26-gauge sheet metal attached to lower surface with visco-elastic compound	1.37	(.054)	56	2.54	(.52)	7.2	3.90	(0.36)
10.	Asphaltic undercoating troweled on lower surface	1.70	(.067)	85	2.05	(.42)	6.8	0.64	(.06)
11.	Same material	3.25	(.128)	85	3.90	(.80)	9.9	1.20	(.11)

1/ Test conditions: plate size, 23 x 33 cm (9 x 13 in.); peanut drop height, 46 cm (18 in.); peanut flow rate, 540 kgm/hr (1200 lb/hr); microphone location, 30 cm (12 in.) above plate. Values of treatments 1, 5, 6, 7, and 8 from one test only; all others averaged from 2 tests.

2/ Based on full plate size.

also shown for selected treatments in Figure 17. The food-conveyor-belting treatment was the most effective for noise reduction, although only slightly exceeding the better of the remaining treatments. Purchased new, this material is quite expensive; however, it is often available as surplus at some processing plants, and should be considered for use in noise reduction treatments in such instances.

A variety of treatments to the lower surface of the metal were evaluated for noise attenuation. Treatments 2 through 4 were commercial materials developed in recent years specifically for damping metal. The materials can be applied by spraying or troweling. The material used for treatment 2 was efficient, based on weight of application, and should be considered for use if weight is critical. Such an application might be on a component of a vibrating separator.

Other materials developed specifically for efficient damping were obtained in sheet form. Treatment 5 was furnished with an adhesive layer for attachment and treatments 6 through 8 were magnetically attached. These materials are quite expensive and generally would be used only in specialized applications. The magnetic material is intended primarily for experimental purpose to determine the value of damping treatments at specific locations.

The constrained-layer treatment, treatment 9, consists of a thinner and somewhat smaller sheet (40 to 60 percent area) of metal attached to the center of the parent metal with a visco-elastic adhesive. The adhesive manufacturer recommended placement of 3 mm (1/8 in.) beads of adhesive diagonally across the small sheet 5 cm (2 in.) apart and around the perimeter of the sheet, with a 0.4 to 0.8 mm (1/64 to 1/32 in.) space between the sheets. Performance of this treatments was satisfactory; however, it would be somewhat more difficult to apply especially to

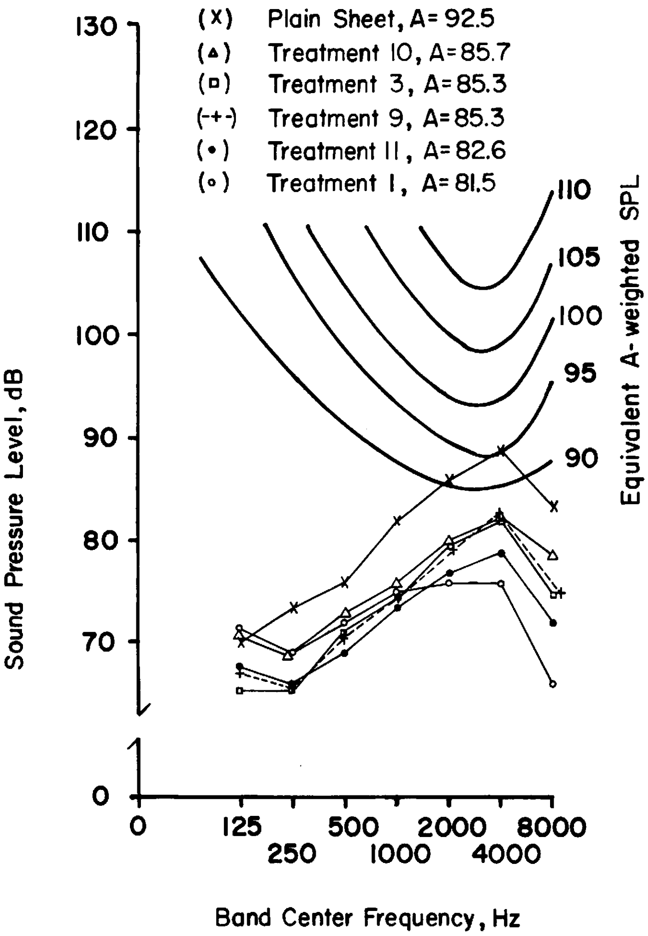

Fig. 17. Comparison of effect of selected damping treatments.

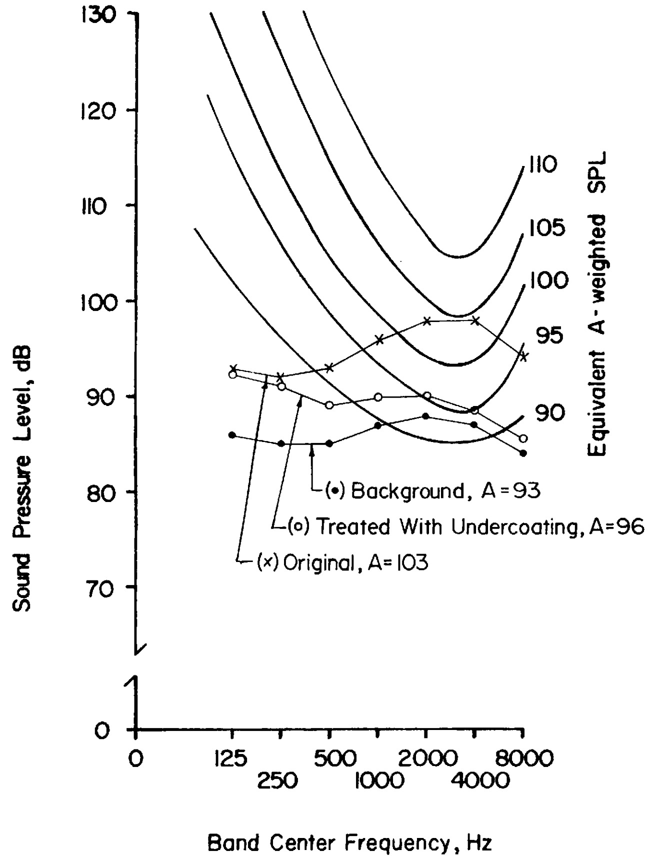

Fig. 18. Comparison of near-field sound pressure level of chute before and after treatment with undercoating.

curved surfaces. Often, sheet metal is available as scrap, and if scrap is used, the treatment cost is considerably lower, since the adhesive is only \$0.90/m^2 (\$0.08/ft^2) of the total cost.

Treatments 10 and 11 were two weights of automotive undercoating, a widely used asphaltic formulation. The heavier treatment performed better than any other lower—surface treatment, and was also less expensive than the other materials. Unless treatment weight is critical, this material is generally recommended. It can be sprayed or troweled; however, multiple coats may be required to obtain the desired thickness. Also, several days are required for curing.

The undercoating treatment was applied to numerous chutes, hoppers, etc. in the NPRL pilot shelling plant to evalute the effectiveness in a field application. The results for a typical chute are shown in Figure 18, and for the overall noise level in Figure 19. These results indicate a satisfactory reduction in overall noise level.

Our experience has indicated that plastic roof-patching cement, a stiffer formulation of asphaltic mastic, performs equally as well as the undercoating; although it is not sprayable due to its thicker consistency.

Other materials are available for reducing noise from metal surfaces. For example, a laminant of sheet metal bonded to a layer of rubber is available commercially which would undoubtedly be effective if used in appropriated places in peanut processing equipment. Although quite expensive, the material could perhaps be justified by a manufacturer for selected applications. Recall from Figure 7 that thicker metal is some what quieter. However, heavier metal cannot be justified solely from the standpoint of noise reduction. considering cost and weight, other materials applied to the thinner metal provides much more effective noise reduction.

A consideration in selecting a damping treatment is fire hazard rating. Penalties in fire insurance rates can result from introducing material to the plant which has an unfavorable rating. However, ratings used among manufacturers and insurance organizations vary widely and are quite confusing. Montone (1) queried 200 manufacturers of acoustical material and found that only 32 percent of those responding provided fire related specifications. Of the 32 percent, eight different types of classifications were employed. He questioned the validity and lack of standardization of the rating systems and

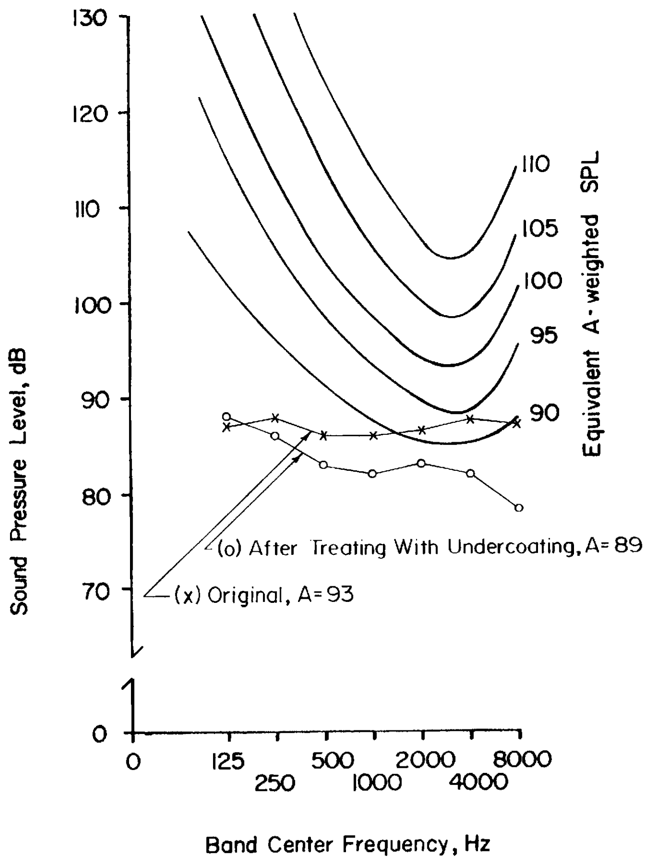

Fig. 19. Comparison of sound pressure levels in aisle of pilot shelling plant before and after treating with undercoating.

suggested comprehensive reassessment and revisal of fire hazard ratings. Because of this confusion, we have not attempted to rate these materials for fire hazard, but plant operators should be aware of the situation and consult the insurance underwriters and material suppliers in this regard. The undercoating used in our evaluations carried a combustible warning due to petroleum naptha content. However, other asphaltic undercoatings are available at comparable prices with ratings which indicate minimum fire hazard, such as: "no flammability," "non-flammable," "ASTM-E-162 Class I," or "ASTM-E-84 Class I."

The effect of temperature on performance of the damping materials was not evaluated. Our results were obtained at "normal" room temperature—about 24^0 C (75^0F). Information from some suppliers indicates that the damping properties decrease rapidly at elevated temperature; however we feel that normal plant temperatures will not vary enough from our test conditions to significantly affect results.

Conclusions and Recommendations

Particles impinging on metal surfaces in peanut processing plants cause increased SPL's at critical frequencies. Plant noise levels can be reduced significantly by applying the following recommendations:

1. Reduce particle velocities wherever possible by using horizontal conveyors, bin level control devices, easy letdowns, or similar innovations.

2. Arrange feeder pipes and install baffles to allow falling peanuts to strike other peanuts instead of metal surfaces.

3. Insulate easily encloseable sources (such as closed-off pipes) with fiber glass or other noise barriers.

4. Treat upper surfaces of metal chutes with a resilient material such as food conveyor belting; or, treat lower furfaces of chutes, troughs, transitions, ets., with a damping material. A heavy coat of asphaltic mastic is generally recommended.

Acknowledgments

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