Impact of Noise on Safety With Special Reference To Pulp And Paper Industry

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Manufacturing activity deals with the transformation of materials of low utility to high utility through a series of changes both physical and chemical. These changes are brought about in a well organised sequence with proper parameter control in various processing equipments, machines and material handling systems. Thus Manufacturing is a continuous dynamic interphase between man, machine and environment and each worker in a paper mill performs his job as a part of network called man, machine environment system. Ref. fig. (1).

Eversince the industrial activity began the question of safety and accident prevention have come to focus. The occurance of an accident is basically due to the violation of safe practice and can occur due to failure of any of these parameters.

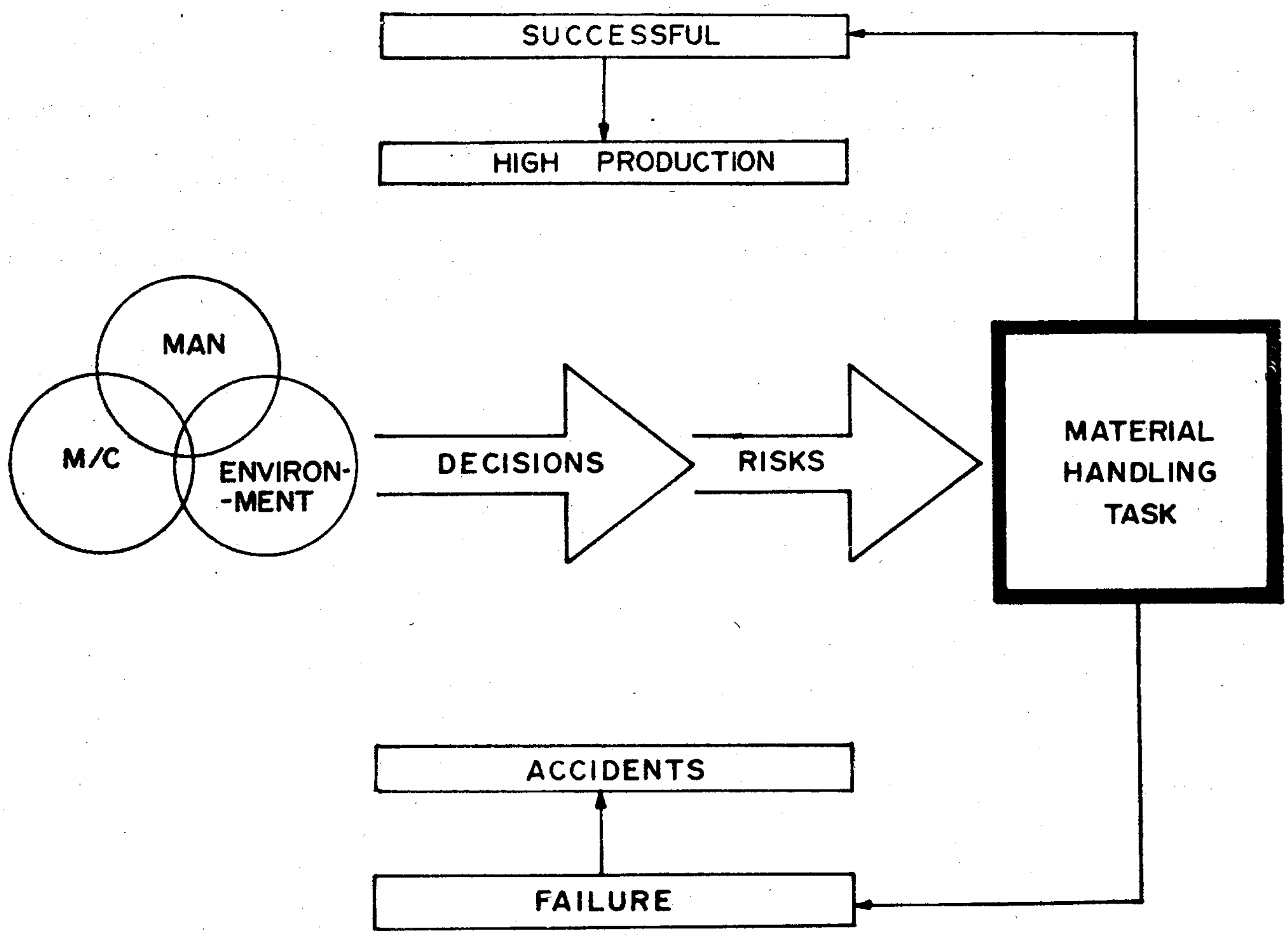

FIG. NO-1

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In the above network (Fig. 1) which can also be called as a manufacturing equation, man and machine work in the environment. The man and machine factors have received significant attention in the recent years. However. the environmental factors which also affect the performance of a man significantly are not considered seriously. These factors include Illumination, Temperature, Hours of work, Noise etc. Of these illumination and temperature have received significant attention and noise is yet to receive due attention to improve the performance of a man and thereby reduce the risk of industrial accidents.

2. ENVIRONMENTAL FACTORS EFFECTING PERFORMANCE :—

The factors effecting the performance of a man are
Illumination
Temperature
Hours of work
Noise etc.

There is rarely a single or specific cause of an accident. Following two factors may be a cause of an accident.

(a) Personal
(b) Environmental

When the environmental factors are considered it is observed that the chances of accidents are as follows:

1.	Material handling	26.1%
2.	Rotating machines	19.7%
3.	Persons falling	15%
4.	Striking against objects	8.1%
5.	Falling bodies	8.1%
6.	Transport	6.7%
7.	Other changes	8.8%

Material handling and rotating machines are responsible for more than 45% of the accidents and in process industries these are the important areas. Noise is associated in a bigway in these locations. The level of noise. intensity of noise and permissible noise exposure levels are receiving attention of process engineers and process technologists in the recent years.

3. NOISE AND NOISE POLLUTION LEVELS :

3.1. Noise pollution level : (NPL) is defined as :

$$L_{np} = Leq + 2.56\ \delta\ dB$$

where L_{nq}=is the quantity symbol for noise pollution level

δ=is the standard deviation of the instantaneous levels sampled during the period of measurement
Leq=is the equivalent continuous sound level

3.2 Sound Pressure level : The sound pressure level Lp is expressed in decibels as 20 log p/po

where p is the measured sound pressure po is the reference sound pressure expressed in the same units as p and is equal to 2.10^{-4} N/m^2 (rms).

Ref. IS: 6098 – 1971 pp[3].

3.3 Sound Power Level : The sound power level Lp is expressed in decibels as $10\ \log \frac{P}{Po}$

Where P is the measured sound power (watts) and Po is the reference sound power expressed in the same units as P and is equal to 10^{-12} watts (or 1 p.w) Ref. IS: 6098–1971 pp[3].

3.4 Acceptable and Dangerous Levels : Needy (1959) considered that tympanic membrane could rupture at 160 dB. The maximum permissible level which the ear can tolerate without sustaining permanent damage is dependent on the exposure time. Pfander (1965) considers 165 dB permissible for 0 003 sec/day but for 0.3 sec. only 145 dB can be tolerated.

Three tolerance levels are described by Glorig, (1958), the threshold of discomfort 120 dB. tickle 130 dB, and pain 140 dB noting that they also vary both individually and with experience.

The most frequently used noise limits are –

(i) Residential area 55 dB—day
45—50dB Night

(ii) Industrial regions 70 dB for both Night & Day.

Table below indicates the permissible noise exposures currently associated with most occupational safety and health standard.

Table—3, 4 (a)

Sl. No	Duration/day in Hrs.	Sound Level dB.
1	8	90
2	8	92
3	4	95
4	3	97
5	2	100
6	1.5	102
7	1	105
8	0.5	110
9	0.25 or less	115

Table—3, 4 (b)

External noise exposure standard from U.S. deptt. of housing and urban development

Sl. No.	Noise Levels	Category
1.	Exceed 80 dB. for 60 min/24 Hrs. or 75 dB for 8 Hrs/24 Hrs.	Unacceptable
2.	Exceeds 65 dB for 8 Hrs/24 Hrs.	Normally unacceptable
3.	Does not exceed 65 dB for more than 8 Hrs/24 Hrs.	Normally acceptable
4.	Does not excced 45dB for more than 30 min/24 Hrs.	Acceptable

Table—3, 4 (c)

For safe duration exposure

S No.	1	2	3	4	5	6	7	8
Hz	63	125	250	500	1,000	2 000	4,000	8,000
dB	103	96	91	87	85	83	81	79

The hazardous level of 1 KHz for an exposure of four hours is 85 dB, whereas for shorter periods higher frequencies are permissible.

For a 7 min exposure the same frequency for instance, the level rises to 107 dB.

A review of existing damage risk criteria (Action and Carson 1967) considers that for everyday purposes a single 90 dB measurement is the most practical criterion. It also considers it unwise to allow unprotected ear exposure to level exceeding 135 dB for steady state noise, no matter how short the exposure time is.

Noise injury at first develops rapidly, later more slowly and come eventually to a standstill, dependent mainly on the noise level.

3.5 White and Pink Noise : White (fluctuation or random) noise is a sound spectrum containing a mixture of all frequencies throughout the whole audible range, all generated at equivalent sound pressure levels.

Pink noise has similar frequency characteristics to white noise. All frequencies are again of the same amplitude but the sound is of much greater intensity, above the damage risk criteria (DRC) and threfore potentially hazardous to hearing.

4. NOISE IN PAPER INDUSTRY :

Paper Industry is a major culprit in sound pollution, as is the case in other areas of pollution namely liquid gases and solid effulents. Chipper house digester blows, evaporator operations, boiler sections, recovery furnaces are but some of the important locations associated with high noise levels. Scanty information is available on sectionwise noise levels and their impact on worker performance and accident rates.

4.1 Specific Areas in Paper mill (case study) where Noise Level is High :

Chipper House : Chips are produced and handled in the chipper house. During chipping the crew faces ambient noise pollution. Ambient noise is the noise associated with the given environment due to various machines and machining operations. Most of the m/c developed for industriat purposes including paper mill are accompanied by noise. Noise is the unwanted sound, generally of random nature, the spectrum of which does not exhibit clearly defined frequency component.

The noise in the chipper house is primarily due to rotating machines which is of continuous nature superimposed by the impulsive noise. The result of such combination noise to periodic peaks which may be usually 104 dB. may cause chronic noise trauma as found by Feiser, Hanf and Henft (1968).

5. ANALYSIS OF NOISE IN PAPER MILL (CHIPPER HOUSE)

For analysis purposes the noise in the chipper house can be basically considered due to—

5.1 Chipping/dropping of woodenlogs in the chipper and vibrofeeder.

5.2 Rotating machines.

5.1 The noise produced by chipping/dropping of wooden logs/bamboo is described as an impulsive or impact noise. Its characteristics are such that its effects on auditory functions can be much more damaging than those due to more conventional industrial noise sources. Separate damage risk criteria have been proposed for impulsive noise to give same guidance as to its tolerable safe limits.

The term impulsive noise involves a change in sound pressure above some reference value (usually 40 dB). The transient acoustical event is of very short duration (usually less than 0.5 (seconds). Thus the sound pressure rises abruptly and then decay over a short time interval. The peak pressure may range from 110 dB to as high as 190 dB. Two types of impulsive noise are distinguished—

The Ist type impulsive noise involves a rapid rise to peak sound pressure level followed by a decay

The IInd is oscillating Ref. Fig. 5.1

Duration of the single event is usually taken as the time required for the envelope of the oscillation curve to decay to a value 20 dB below the peak value of the pressure level.

Cohen, Kylin and La Ben (1966) published the first study on industrial semi impulse type of noise. They consider that with impulsive noise it is unwise to relax aural protection even for a single exposure. They derived an impulsive noise Damage Risk Criteria (DRC) based on repetition rates in the order of 6-30 impulses/min and exposure of 100 impulses/occasion on perhaps 10 occasions/year. They noted that with ear protection 10 dB could be allowed for ear plugs and 35 dB for fluid sealed earmuffs.

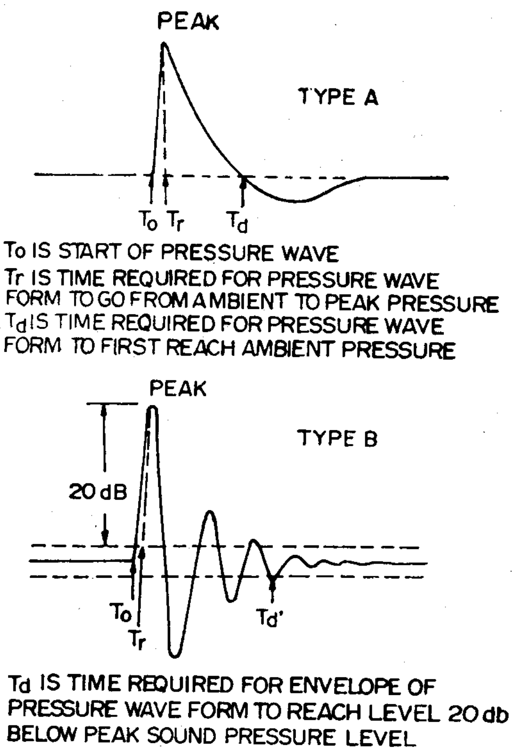


FIG. 5·1 IDEALIZED PRESSURE WAVEFORMS. TYPE A REPRESENTS A SINGLE, HIGHLY DAMPED IMPULSE IN A NONREVERBERANT SOUND FIELD. TYPE B REPRESENT DAMPED OSCILLATIONS, SHOWING THE INFLUENCE OF THE REVERBERANT SOUND FIELD

The chipper house impulsive noise can be studied as—

1. Occasional discrete noise
2. A rapid and continuous series of, discrete impulses. A striking rate of 1/sec. means 30,0.0 impulses in an eight hour working day and over 300 working days/year.
3. Series of impulses occuring so rapidly the noise from one decay from its peak by only a few dB before the next arrives—a typical chipper house noise.

For type (1) the impulsive DRC is applicable, for type (2) no criterion can be applied, (3) steady state DRC are adequate.

To access potential hearings damage from impulsive noise, the peak pressure magnitude, the time duration and the number of impulses per unit time are to be considered. If the number of impulses during chipping operation exceeds 10 per second the nolse in the chipper house can be treated as continuous instead of impulsive. If the average interval between impulses is 1 to 10 seconds the peak level is reduced by 5 dB. The rise time of the impulsive noise may be as low as 0.001 seconds or even less. Impulsive noise is more annoying than a steady noise having the same overall energy contents.

A noise peaking 165 dB lasting for 1 second delivers the same amount of energy to the ears as 115 dB noise continuously experienced for 24 Hours.

A daily impulse noise exposure exceeding 145 dB for a period of 10 years cause a 5 dB hearing threshold shift for the 4000 Hz test tone. If the noise due to chipping has a duration of less than 25 μs a peak level of 167 dB will produce the same effect. Thus the duration of the impulses should be regulated to allowable maximum levels for protection from hearing defficiency.

5.1.1 Safe Operating Limits of Chipper (Maximum levels for a fraction of time) :

In the chipper house the noise of high intensity and short duration occure that effectively establishes the (Leq.) level over a longer time span.
Lequ. is given by :—

$$Leq. = 10 \log \left(f1\, 10^{L1/10} + f^2\, 10^{L2/10} \right)$$

L1 is the high intensity source level that lasts for f1 fraction of time.

L2 is the low intensity source level that lasts for f2 fraction of time.

$$\text{If } f1\, 10^{L1/10} = 10 \left(f2\, 10^{L_2/10} \right) \text{ Assumed}$$

Then

$$Leq = 10 \log \left[f1\, 10^{L1/10} + (0.1)\, f1\, 10^{L1/10} \right]$$
$$= 10 \log \left[(1.1\ f1)\ 10^{L1/10} \right]$$
$$= 10 \log 1.1 + 10 \log f1 + L1$$
$$= 0.4 + 10 \log f1 + L1$$
$$= 10 \log f1 + L1$$

The above equation is useful in establishing how long a chipping operation should be carried out at a stretch so as not to exceed the desired level (Leq) over a specified period. Conversely knowing how long the chipper can be operated to control the magnitude of Leq, will help us as a guide line for the safe handling of chips. The above concept can be examined with the following example :

Example :—A chipper of 375 HP capacity operates at 80 dB say. In 24 Hours how many times it can be allowed to operate continuously so as not to exceed Leq. of 68 dB. Let us assume that a level of 55 dB is already existing when the chipper is not operating.

From the above discussions —

We have $Leq = 10 \text{ Log } f1 + L1$
$L1 = 80$ dB ; $Leq = 68$ dB
$68 = 10 \log f1 + 80$
$10 \log f1 = 68 - 80 = -12$
$\log f1 = -1.2 = (8.8 - 10)$
$f1 = 0.063 = 6.3 \times 10^{-2}$
$f2 = 1 - f1 = 0.937$
$f1/f2 = 0.063/0.937 = 0.0672$
$t = f1 (24)\, 60 = 0.063 \times 24 \times 60 = 1.512 \times 60$

$t = 90.8$ minutes. Thus the chipper can be operated for 90.8 minutes continuously. From the above calculation let us examine the value of t for different values of L1, keeping Leq same as 68 dB.

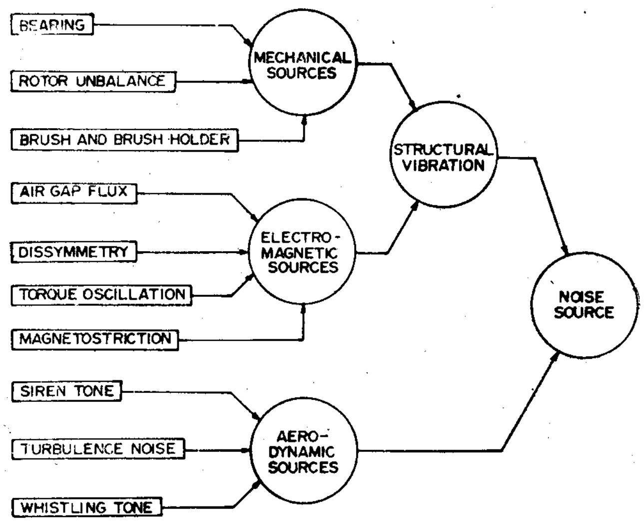
Table 5 1.1

S No.	Leq, dB	L1, dB	t
1	68	80	90.8 minutes
2	,,	85	28 ,,
3	,,	90	9 08 ,
4	,,	95	2.9 ,,
5	,,	100	0.9 ,,
6	,,	110	0.09 ,,
7	,,	120	545 milli seconds
8	,,	130	54.5 ,,
9	,,	140	5.45 ,,
10	,,	150	0 545 ,,

5.2 Noise due to Rotating Machines:

A machine is any sound source of which acoustical characterisics are to be measured (IS : 4758 : 1968). Industrial machinery in paper mill and chipper house in particular cover a wide range of such instruments. The noise sources in the electric motors are broadly categorized as :

(a) Mechanical (b) Magnetic (c) Ventilation



SOURCES OF ELECTRIC MOTOR NOISE.
FIG NO-5·2

The noise produced by mechanical sources is associated with the bearing assembly. It can be appreciable if the bearing parts are deformed in some manner or if excessive clearances permit axial travel of the shaft. Usually mehanical noise is due to mechanical unbalance of the rotor shaft assembly.

The magnetic effect also produce noise. It originate from periodic forces which are in the air gap between rotor and stator. The magnetic forces causing noise are due to many mechanical and electromagnetic properties of the stator — rotor assembly.

Sound level ranges of the equipments generally used in paper mill (chipper house)

Table 5 2 (a)

1.	Scrappers	80
2.	Trucks	75
3.	Cranes	75
4.	Pumps	75
5.	Generators	75
6.	Compressor	75
7.	Pneumatic Wrenches	80
8.	Vibrators	75
9.	Saw	75
10.	Ballast clearing m/c	80

Sound power levels for squirrel cage induction motors of standard construction under NO LOAD in dB. (re Picowatt).

Table 5 2 (b)

No. of poles	Synchronous speed	H.P.	dB	dB*
8	900	75–100	87	93
8	900	50–60	84	89
8	900	30–40	81	86
8	900	20–25	79	83
8	900	10–15	76	80
8	900	5–7.5	73	76
8	900	2–3	70	72
8	900	1–1.5	69	69

* Totally enclosed fan cooled m/c.

In paper mill D. C. motors are also used where variable speed is required as in case of cranes etc,

Sound levels for D.C. motors (TEFC) (SV) totally enclosed Fan cooled or self ventilated is given below.

Table 5 2 (c)

S. No.	H.P.	Sound level dB
1	125–150	80
2	100	68
3	60–75	69
4	40–50	69
5	25–30	69
6	15–20	69
7	7.5–10	62

6. EFFECT OF NOISE STIMULATION :

Stimulation of ear with noise causes —

1. Adaptation
2. Temporary threshold shift
   (a) Fatique
   (b) Temporary stimulation deafness
3. Persistent threshold shift
4. Permanent threshold shift

The physiological effects of noise can be –

(a) Short term effects
(b) Long term effects

The short term effects outlast or persits for miuutes with associated affects such as fatigue head-ache. Long term effects are measurable in hours or days.

Muscle Tension Responses : In laboratory short duration pules (2 sec) of 1 KHZ at a pressure of 70. 90 and 120 bB were applied. The muscle activation detected by EMG. The increased muscle tension is the mechanical result of increased activity in the motor neurons.

Respiratory Reflexes : Breathing is influenced by short sound stimuti. Experiments on human body show that short (2 sec) tone pluses of 1 KHZ frequency at sound pressure level of 70, 90, 120 dB slower breathing movements.

Heart Rate : Heart rate study produce a confusing range of results. White noise of sufficient intensity elicits an increase in heart rate. Exposure to a wide range of noises extending over a range in A weighted sound level of about 90dB. sudden onset appear to produce a moderate rise in heart rate.

Exposure of 1 Hour duration to broad band noise in moderate to higher sound levels have been reported to lower the heart rate.

Flood Pressure : Noise from a circular saw having 110 dB sounb pressure produced little changes in systolic pressure (a measure of minimum arterial pressure) tended to rise.

Annoyance : Psychological reactions to noise is expressed by 'annoyance factor'. A noise is expressed to be annoying if the exposed worker would redoce the noise, avoid or leave the noisy area if possible.

Aggressiye Behaviour : There is more risk of hostile behaviour in noise. The studies confirm that persons report themselves more irritable and less self-controlled after noise exposure.

Eflect on Memory : noise is sxpected to produce changes in memory.

7. NOISE CONTROL :

The noise control problem is fundamentally represented as :

M/C Source, path, Operator,

There is little opportunity for noise control at the operator point.

Permissible noise levels are set for the receiver and techniques are used on machine and/or path in order to limit the exposure of the operator. Thus there are three ways to eliminate the noise—

(1) Eliminate sound at SOURCE.

(2) Modify the path along which the noise is transmitted.

(3) Provide the receiver with some form of protection.

Reduction of noise at source : Machines should have quiet bearings, smoothly running working parts and effective silencers. Sound absorbent mounting will cut down transmission of structural vibrations in building, sound absorbing surfaces such as porous acoustic tiles will reduce sound reflection and reverberation and it may be possible to enclose certain machinery completely within sound proofed cells or acoustic guards. Baffles may be useful in absorbing and deflecting sound emanations.

Second primary area is the proper operation. All equipments should be operated at the design conditions.

The third primary area is the equipment maintenance. It should be apparent that maintenance is an important element in controlling the noise geaerated by equipment. Maintenance departments should be instructed that noise is a very important consideration in all of their activities.

Modification of the path includes increasing the distance between the source and the receiver and orientating the source so that the radiated power directed at the receiver is a minimum.

In situations where neither source modifications nor path modifications can reduce the sound to acceptable levels, direct protection of the individual is necessary. Personal ear protection equipment include ear muffs, ear plugs. Small sized noise dosimeters can be worn to access the risk of hearing loss as prescribed by federal and state regulations.

8. CONCLUSION :

The above study on the "Impact of noise on safety with special reference to paper industry," reveals that the accoustic accidents are usually occuring in paper industry during the handling of materials. To reduce such accidents which impair the production following steps should be taken :

1. Workers should be made aware that their hearing is "at risk". Aural protection should be encouraged whereever a potential noise hazard exists as is the case identified (chipper house) in paper mill.

2. Environmental noise pollution should be recognized as a serious threat to the workers and occupational safety and health act should be formulated considering the allowable occupational noise levels with reference to paper industry, sectionwise.

3. Medico legal aspects : Noise induced hearing loss is not prescribed as the industrial disease and is not eligible for compensation, however the loss of faculty due to noise shuld be checked in view of prevention of accidents.

4. The noise levels should be recorded regularly and should be considered as an important indirect process parameter over which the plant efficiency depends.

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