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IIT(BHU) VARANASI

STUDENTS' NOTES

SOUND PRESSURE LEVEL

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- Sound Pressure level is ratio between two sound energy level

- $L_p = 10 \log\left(\frac{I}{I_r}\right) = 10 \log\left(\frac{P}{P_r}\right)^2$

$P_r = 20\,\mu Pa$

$= 20 \log\left(\frac{P}{P_r}\right)$

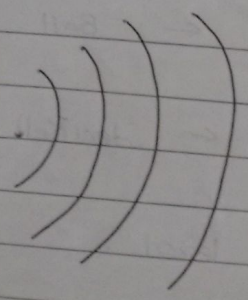
Lowest = 0 dB ⇒ $P = P_r = 20\,\mu Pa$

Highest = 120 dB

0dB – 120dB is audible limit

also 20 Hz – 20 kH is audible limit

Sound Power level



$N = I \times S$

N = Sound Power Level

S = Area through which energy is passing

The Acoustic Power of an equipment may not change materially for any change in its location, hence it can be

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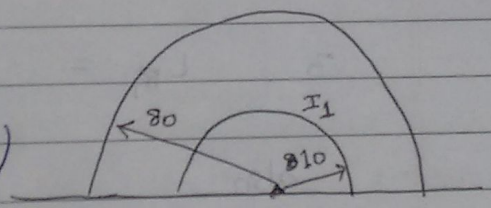
assumed to be constant unless some internal changes occurs

However total sound pressure level in a given system may change depending upon resonance effect in relation to other structures.

Q. If SPL at 10m distance from a machine on a floor is 118 dB. Find SPL level of machine at 80m distance and Power level?

Ans Given,

$$118 = 10 \log\left(\frac{I_1}{I_r}\right)$$



$$I_1 = 10^{11.8} \ W/m^2$$

Sound power level $= 10^{11.8} \times \pi \times (10)^2$

$= \pi \times 10^{13.8} \ W$

$= 3.14 \times 10^{13.8} \ W$

$$I_2 = I_1 \times (10/80)^2$$

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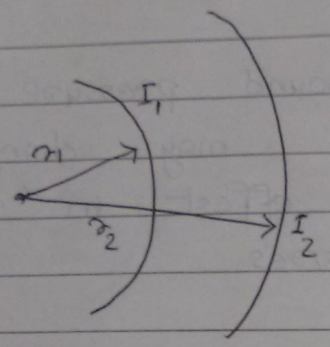
Effect of Distance



$$L_{R_1} = 10 \log\left(\frac{I_1}{I_{ref}}\right)$$

$$= 10 \log\left(\frac{N}{4\pi r_1^2 \, I_{ref}}\right)$$

$$L_{R_2} = 10 \log\left(\frac{N}{4\pi r_2^2 \, I_{ref}}\right)$$

$$\therefore L_{R_1} - L_{R_2} = 10 \log\left(\frac{r_2}{r_1}\right)^2$$

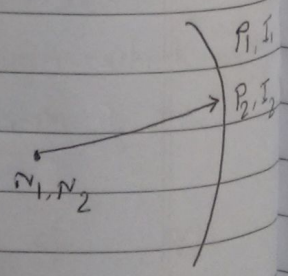
$$\therefore L_{R_1} = L_{R_2} + 20 \log\left(\frac{r_2}{r_1}\right)$$

also,

$$\therefore L_{P_2} = L_{P_1} - 20 \log\left(\frac{r_2}{r_1}\right)$$

Addition of SPL

Combined SPL =



$$10 \log\left(\frac{I_1 + I_2}{I_r}\right)$$

$$= 10 \log\left(\frac{P_1^2/\rho c + P_2^2/\rho c}{P_{ref}^2/\rho c}\right)$$

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- For n sources,

$$L_p = L_I = 10 \log \left(\frac{P_1^2 + P_2^2 + P_3^2 + \dots}{P_{ref}^2} \right)$$

$$I_{ref} = \left(\frac{20 \times 10^{-6}}{1.2 \times 10^{-6} \times 330} \right) = 10^{-12}.$$

- If sources are same,

$$P_1 = P_2$$

$$L_{p_{new}} = 10 \log \left(\frac{2P^2}{P_{ref}^2} \right) = \log 2 + L_{p_1}$$

So, 80 dB + 80 dB = 83 dB

Q. If pressure of sound source is doubled, what will be new pressure?

Combined SPL of two sources can be approx

Diff b/w values	Add this to higher dB value
0	3
1	2.5
2	2
3	2
4	1.5
5	1

I_1

I_2

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diff btw two dB values	Add this to higher dB value
6	1
7	1
8	0.5
9	0.5
10	0

Q Resultant of 96, 93, 90 dB ?

Ans

96
93 > 95 > 98.5
90

Permissible Noise Level

90 dB (A) is the permissible limit of noise in most country for 8 hrs shift according to ILO

OSHA (Occupational Safety & Health Administration USA) gives the table 2.

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Impulse → Difference b/w

Noise Exposure Index

$$NEI = \frac{t_1}{T_1} + \frac{t_2}{T_2} + \dots$$

t_i = Total time of exposure at a specified noise level

T_i = max permissible exposure at that noise level

NEI > 1 is not permissible

ie. NEI ≯ 1

Table 2: Max Exposure (hrs/day)	SPL (dB)
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25	115

Continuous SPL should not exceed 115 and Impulse noise 140

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Q. A worker is exposed to noise in his 8 hr shift given.

3 hrs – 90 dB

2 hrs – 92 dB

1 – 96 dB

Examine if it is within permissible limit

Ans $\frac{3}{8} + \frac{2}{6} + \frac{1}{3} = \frac{25}{24} > 1$

Equivalent SPL (L_{eq})

$$L_{eq} = \frac{\log F}{0.1} + 90$$

where,

$F = \Sigma f_i$, $f_i = \frac{t_i}{8} \text{antilog}[0.1(L_i - 90)]$

L_{eq} = Equivalent Sound Pressure level

F_i = Total Exposure Factor

f_i = Fractional Exposure Factor

t_i = time of exposure

L_i = SPL corresponding to t_i

L_{eq} is continuous and steady SPL which would have same acoustic energy as real

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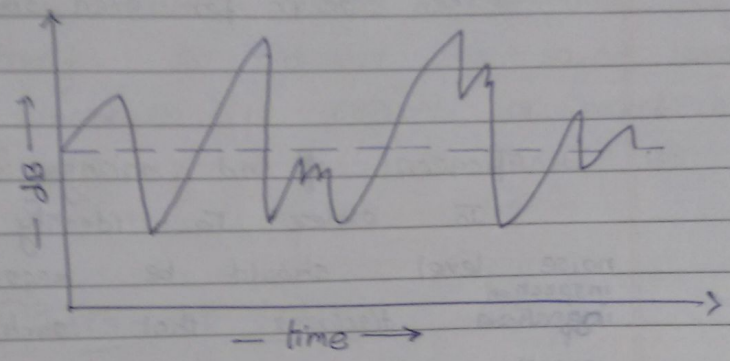
fluctuating noise over same time period.



Salient Features of Indian Regulation

(Gr no. 18/1975 (Tech))

A) Based on ILO Code of practice

(i) 85dB(A) : Warning 8hrs

(ii) 90dB (A) : Danger level (a worker may be temprarily authorised to work under this condition if on the next day he is provided recumperation (rest).

(iii) 115 dB (A) : Workers shouldn't be allowed to enter such area without ear protection

(iv) Personal Protective Equipment (PPE) shall be worn of single isolated outburst can go above 130 dB(A) - impulse noise or 120 dB(A) - fast noise

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(v) > 150 dB(A) : No entry even with PPE as more damage can occur for even smallest exposure

(3) Identification of and making of risk area:
In order to identify risk area noise level should be measured (a) when inspection discloses that such risk may exist

(b) workers complain

(c) Speech intelligibility impaired (Baat Sunai Nahi De Raha) at a distance of 50 cm

(d) making of following risk and areas should be indicated clearly

(i) Equipment producing noise more than 85 dB

(ii) Display prominently a suitable sign forbidding entry to all except wearing PPE

Permissible Exposure level of Peak SPL (dBA)	Impact permitted no. of impacts / day
120	10,000
125	3,160 ↓ 1/3
130	1000
135	315
140	100

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H.A → Constructional Features of ears regarding hearing system.

mid.org.uk
sasked.gov.sk.ca

With increase in every 5dB(A), no. of impacts is reduced to 1/3rd generally. Human ears are not very sensitivity to change in sound level. An increase in 5dB(A) is percieved significantly

Effects of Noise

(a) Permanent Threshold shift when person can't hear consonent due to fall of corti

(b) Due to damage of eardrum person becomes - stone deaf

Critical SPL and Effect

L_p(dBA)	Type of work > 5hr	Human Reaction
		Communication
100	> 5hrs Hearing Damage	Very Difficult
90	Nervous System	Difficult
80	Construction	Raised voice
70	Equipment Assembly Affect mental state	Normal
60	Lab offer	
50	Special Attention Required	
40	Voice Regarding extreme attention	

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Effect of Noise

(a) Auditory System : Hearing loss.

(b) Non-Auditory Effects :

Besides having loss, it affects mental and physical health in many ways :-

(i) Physical - it affects physiological function :- Blood Pressure, breathing amplitude increases, blood cholesterol, changes in gastric secretion, blood circulation

(ii) Physiological - Change in personal and social behaviour, interference with sleep, loss in concentration

(c) Task Interference - Due to physiological and mental effect, sleep disturbance the performance goes down, loss in production, time for work will increase, error rate increases, cognition task (memory) hampered

Below 90dB also, irregular disturbance are disturbing

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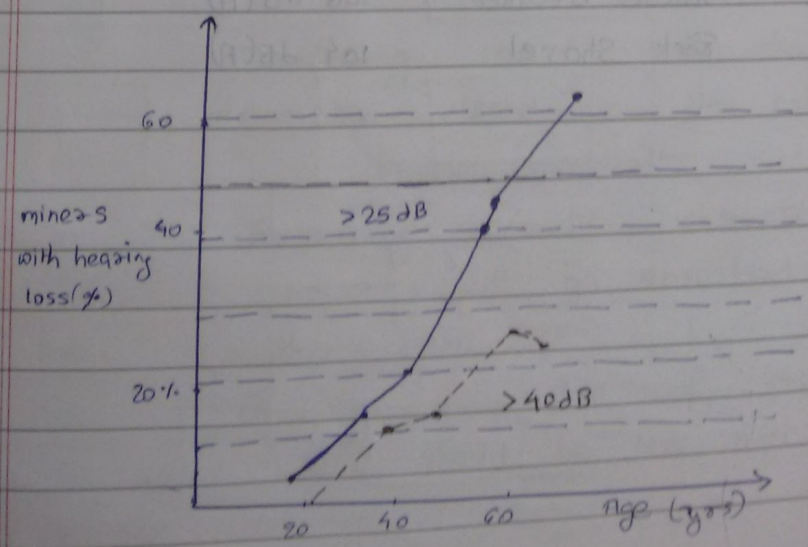
High frequency disturbance are more irritating as the interfere more. Even after the zone of noise, it takes time to calm down.

(d) Masking - Noise interference with the communication is noise masking and may create many problem in mines. eg in ug mine a lot of noise from machine may create masking, haulage signal, cage signal

(e) Effects on Physical Objects due to vibration

Severity of noise problem in mining



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Hearing Damage - > 25 dB (Limit)
Upto age 50 yrs, more than 50% are suffering > 25 dB, more than 30% suffer > 40 dB

HEMM (Heavy Equipment m/c ..) are exposed to high noise levels. In mining ones working processing plant are affected most

In u/g problem is more accute, due to closed space be small volume makes noise repeating

DGMS Circular : 2004
5 / 1990

Jack Hammer	106 dB (A)
Rock Breaker	106 dB (A)
Rock Shovel	104 dB(A)

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Noise Control

Principles of Noise Control

1. Control at Source - It is the most effective approch. It can be done by
   - Low speed of working
   - Proper maintainance, alignment
   - Electrical Equipment,
   - Compressed Air

2. Control at transmission path - By introducing attainment b/w the source of recievers point
   - By increasing distance.
   - Altering the relative orientation of machinery
   - Surrounding source by impervious material enclosure
   - Confining m/c in the chamber (HEMM)
   - Operator closed in the cabin (HEMM, Operator)
   - Increasing acoustic absorption, the noise will be absorbed within the room
   - Reducing the time of exposure, NEI should be less than 1

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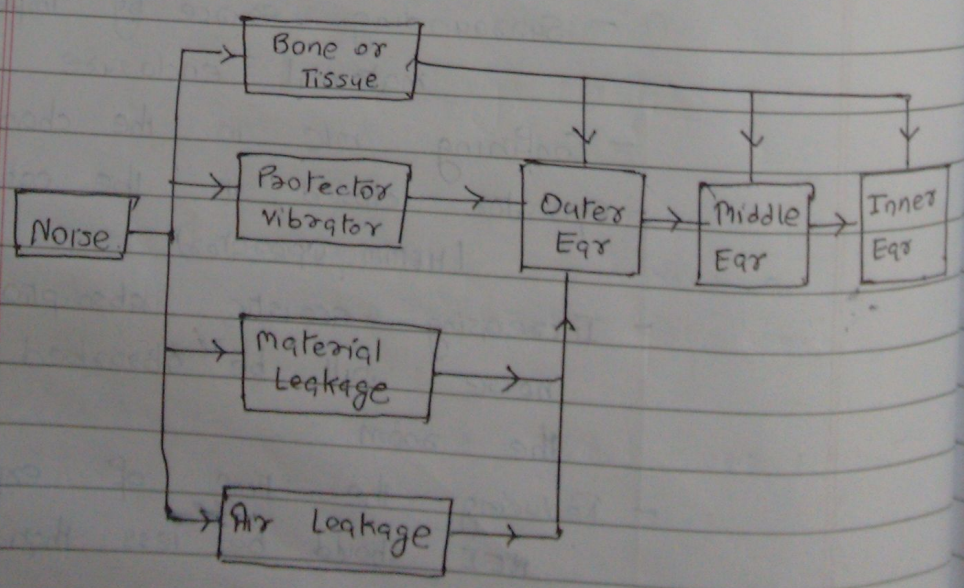
3. PPE / Personal Hearing Protection -

- Ear Plug : Exclusive Energy absorbing foam, having a property of time delayed expansion (that expands and over the earcanal with time). - Fits snuggly

- Ear Muff : Circumferencial Device that protects the passage of sound, externally.

These devices cannot be 100% fullproof and there are many sources of sound leakage

Sources of Leakage



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The efficiency of ear plug and ear muff is very less at low frequency. At higher freq. Air Muffs offer better attenuation than ear plug. A combined system of earplug to earmuff can reduce from 115 dB (A) to 35 dB (A).

Sound Measurement

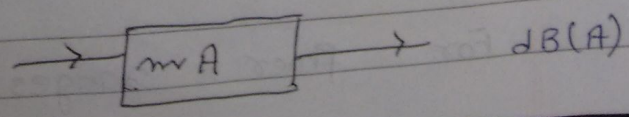
Barrier Comp

(i) Microphone → Transducers which convert any form of energy to electric form of energy.

(ii) Pre-Amplifier → To amplify feeble elec. energy into significant one

(iii) Weighting Network → The instrument reading has to be caliberated with hearing. It modifies the signal to match with human auditory system

The weighting network universally is called "The Circuit A"



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- There are dB(B) and dB(C) but "C" has been discarded.

- In between "B" network took a lead but "A" is universally accepted

- dB(D) is a scale for aircrafts

(iv) Output Amplifier → To amplify the signal as signal is lost in the weighing network

(v) Measurement Device → It can be analog or digital

(vi) Measurement Jack → To take the output

Frequency Analysis

It helps in analysing frequency bands contributing maximum to overall sound level of source

Generally Octave Band is used for analysis.

For finer ranges we go for

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One Third Octave (1/3 Octave)

It consist of Frequency Band Pass Filter which can be of

(i) Lower Pass (F_H) - Upper Cut

(ii) High Pass (F_L) - Lower Cut

(iii) Band Pass - All pass

Difference between F_L and F_H is called Band Width

$$F_L - F_H = \text{Band Width}$$

and Mid Band $= \sqrt{F_L \cdot F_H}$

And when $F_H = kF_L$

if $k = 2$, Octave

$k = \sqrt{2}$, 1/2 Octave

$k = 2^{1/3}$, 1/3 Octave

Standard 1/3rd Octave

Lower Freq (F_L)	Mid (F_0)	Upper (F_H)
22.4	25	28.2
28.2	31.5	35.5
35.5	40	44.7
44.7	50	56.3
56.3	63	70.9

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100, 125, 160, 200, 250, 365, 400, 500, 63
800, 1000, 1250, 1600, 2000, 2500, 3150, 4000
5000, 6300, 8000, 10,000, 12500, 16000, 20,000

Q. In 1/3rd Octave Band Freq Analyser High Pass Filters passes over low cut is 112 Hz, Find Upper cut Mid Band (F_0), and Band Width.

Environmental Impact Assesment

- 1st commercial steam engine using a piston Thomas Newcommen 1712 used to mine out water in an u/g mine in UK
- 1781 - James Watt patented steam engine continuously rotating 10 hp
- 1883 - 10000 hp was produced, as traction vehicle, train and beca key component of Industrial Revolution

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HW - History of Sustainable Development.

USA power outstreamed the European.

- 2nd Industrial Revolution in the form of Bessemer Furnace.

- 1831 - Discovery of electricity by Micheal Faraday
- 1832 - First Electrical Generator
- 1836 - Alexander Graham Bell
- 1850 - Mass production of steel and wrought iron

Sustainable Development

A report named "Limits to Growth" in 1972 by Meadowsehal claimed to establish that the human society is ~~fasting~~ destined to be doomed if we go in this accelerative rate, the human society is destined to get doomed

UNEP in 1973 found the concept of "Ecological Stress". Provision of appropriate technology

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Club of Rome gave the famous slogan of "Halt to Growth".

Several International organisations such as UNESCO, WWF, UNEP, FAO are working on it.

The term sustainable development was first coined by IUCN 1980. It tried to establish a thought of complete change in philosophy and methodology. Environment Protection and Economic Growth need not be mutualy exclusive. the process of sustainable development can render socio - economic development and env. conservation, as to compatible social objective.

3/12/15

Sustainable Development

In 1983, the World Commission of Environmental Development (WCED) also called Brundtland Commission submitted its report for 1987 redefined the sustainable development as,

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The development that meets the need of present without compromising the ability of future generation to meet their needs.

The Objectives are :-

(i) To revive growth.
(ii) Quality of life.
(iii) To meet essential needs - food/job/energy
(iv) To ensure sustainable level of population
(v) To conserve and enhance resource base
(vi) To reorient technology and to manage risk.
(vii) To manage environment & economy in decision making.

In a way the Brundland report ~~point~~ paved the road for United National Conference or Environment Development in 1992 as Earth Summit, Reo De Jenerro

Principle aim of UNCED was to create a workable plan of action which is called as Agenda 21 Summing up the discussion an operational defination has been made.

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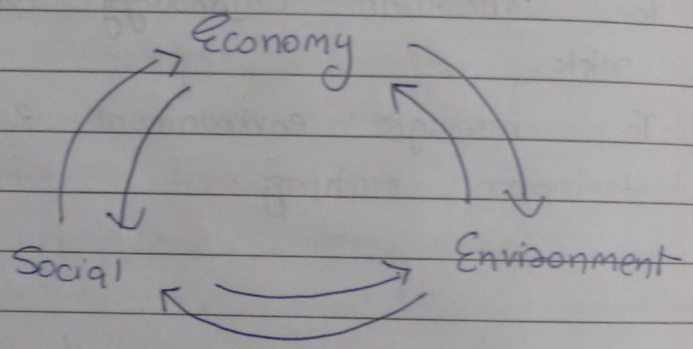
Sustainability can be interpreted as the ability of an ecosystem to maintain long term economic productivity under stress or shock.

Munasinghe (1993) identified 3 interconnected processes :-

- Economic sustainability
- Social Sustainability
- Environmental sustainability



This is known as Input-Output rules of Sustainability -

(i) Total amount of waste material to be generated by any project over a period should be such that the waste can be assimilated by the environment without any loss of capacity to assimilate that quality and quantity of waste in future

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(iv) Input Rule - The maximum rate of renewable resource intake for a project should not be greater than national natural regeneration rate of resource

H.A How to deal with non-renewable resources?

Environment Carrying Capacity

Load that environment can carry

UNCEPA defines as the capacity of natural and human environment to accomodate or absorb changes without accepting the conditions of instability and degradation thereof

Khanna 1989, defines carrying capacity comprises resource which support production activity and in turn produce residuals that are assimilated by the ecosystem.

Carey 1993 -

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Westman 1985 - defines carrying capacity is the level of resources use that can be supported by natural ecosystem without adverse ecological effects.

Based on carrying capacity Goodman 1999 redefined environment sustainable development as development without growth beyond environmental carrying capacity. In other words development is sustainable if it is within carrying capacity.

- Principle consideration for carrying capacity

(i) Capacity of ecosystem to provide natural resource on perpetual basis
(ii) Inter-relation between these resources
(iii) Technology that use these resource in sustainable development
(iv) Waste generated by the process.

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Corporate Social Responsibility (CSR)

The World Business Council For Sustainable Developement in its publication "making good business sense", Lord Holme & Richard Watte used the following defination -

CSR is the continuing commitment by business to behave ethically and contribute to economic developement while improving Quality of Life - (QOL) of the workforce & their family as well as the local community and society atlarge

Traditionally in USA, CSR has been defined much more in Philanthropic Model - "Company makes unhindered profit" except fulfilling the duty of paying taxes. as They donate a certain amount for charitable causes in society.

It is not even binding for the company.

European Model is based on operating the core business in a socially responsible way complimented by the investment in the community. - This model is more sustainable.

The social responsibility becomes an integral part and would enhance

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when ~~Kara~~ gets head.
A few defination -

- Indian Personality
(i) JN Tata - In a free enterprise the community is just not a stake holder, but infact is the very purpose of its existance

(ii) Manoj Chakrobarty - Titan Industries (Tata) - CSR should be in DNA of every organisation. Our process should be allowing so as to benefits the society. If society prospers, so shall the organisation.

(iii) P Muthuraman - July 2004 - MD Tata Steel announces that "In future TISCO would not deal with any company which donot confirm with companies CSR standards

(iv) JRD Tata - in guiding mission - "No material success is worthwhile unless it serves the interest of the country & its people

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