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E-WASTE BY ELECTRICAL WIRES – IMPLEMENTATION OF GREEN SUPPLY CHAIN MANAGEGMENT

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Abstract: The electrical and electronic waste (E-waste) is one of the fastest growing waste streams in the world. The increasing "market penetration" in developing countries, "replacement market" in developed countries and "high obsolescence rate" make e-waste as one of the fastest growing waste streams. Globalization results in both pressure and drivers for Indian citizens to improve their environmental performance. As a developing country, India has to balance economic and environmental performance. Green supply chain management (GSCM) is emerging to be an important approach for Indian citizens to improve performance, possibly on these dimensions. More attentions have been paid to resource usage reduction and ecology protection. The framework is applied to electricity supply through wires within the internal operations of an environmental service. Green product design has received much attention recently, because product design significantly influences the cost component and repair. We investigate the impact of the Eco-design. In this research paper we consider the literature and survey to suggest an Eco-design replica to reduce consumption of wires used in electric supply, according to the energy/power used by the electric wires, used for distribution of supply in residence.

Keywords: E-waste, GSCM, Electrical wires.

I. INTRODUCTION

GSCM is a broader term than sustainable procurement (Bowen *et al.*, 2001a). However, this concept is also related with GSCM practices and can be defined as: *"The process whereby organisations meet their needs for goods, services, works and utilities in a way that achieves value for money on a whole-life basis in terms of generating benefits not only to the organisation, but also to society and the economy, whist minimising damage to the environment" (Purchasing and Supply Agency, 2006).*

The supply chain processes influence the quantities and types of resources acquired and select the source of key products and suppliers; these activities are directly connected with the degree of negative impacts on the environment and indirectly connected with economic and social growth within a community (Morton et al., 2002).

In other words, GSCM is related with any attempt of improving the environmental performance of the purchased products/services or the suppliers that provide them (Bowen *et al.*, 2001a).

The main aims of GSCM are to identify benefits, costs and risks associated with environmental performance (Hanfield *et al.*, 2005). A typical starting point in considering the inclusion of the supply chain is by implementing ISO 14001, which recommends the inclusion of policies to ensure the suppliers are aware of their environmental practices and liabilities (Rao, 2005).

A modern house or building requires electricity to run many of its vital systems such as lighting, heating, hot water, appliances, air-conditioner, TV, Computer & other Electronics Equipments. For this electrical wire or cable is used. The first cables for building wiring were introduced in 1922. These were two or more solid copper wires, with rubber insulation, woven cotton cloth over each conductor for protection of the insulation, with an overall woven jacket, usually impregnated with tar as a protection from moisture. Waxed paper was used as fillers and separators. Insulation of these cables was made of rubber. Aluminium wire was common in North American residential wiring from the late 1960s to mid 1970s, due to the rising cost of copper [1].

Cables can be generally categorized based on voltage range (i.e., low-voltage, operating below about 1000 V ac or 250 V dc, medium-voltage, operating between about 2 and 15 kV ac, and high-voltage operating above 15-kVac) or function (i.e., power, control or instrumentation). The transmission of electrical energy at medium voltages, i.e., at voltages or potentials (V) between about 1 KV and 50 KV, is carried out through electrical cables which typically are connected together via junctions. Electrical cables, in particular low or medium-voltage cables for the distribution of electric energy for domestic or industrial use, generally consist of one or more conductors individually insulated by a polymeric material and coated with a protective sheath, which is also made of a polymeric material [2].

A network of wires drawn connecting the meter board to the various energy consuming loads (lamps, fans, Refrigerator, TV, Computer board, motors etc) through control and protective devices for efficient distribution of power is known as electrical wiring.

Electrical wiring done in residential and commercial buildings to provide power for lights, TV, Computer, Charging, fans, pumps and other domestic appliances is known as domestic wiring. There are several wiring systems in practice. We can treat wires as falling into three general categories as outlined below.

•Solid core (i.e. just one strand of conductor per wire)
•Stranded wire (a bundle of thin strands of conductors)
•Litz wire (as stranded but with insulation between the individual strands)

Different types of electrical wire are available in the market. These wires are used for different application. DC wire used in automobile differs from AC wire used in house wiring. At present no body bother about this difference or not able to differentiate these wires. Our motive in this research paper is to point out the differences between AC and DC wire and also its effect on power losses when AC wire is used in place of DC wire or vice versa which indicates the proper utilization of power though Green Supply Chain Management so that environment will become green and more & more energy is used. This shows that a green planning will at the initial stage and also the awareness in public is needed.

The officially declared transmission and distribution losses in India have gradually risen from about 15 percent up to the year 1966-67 to about 27 percent in 2002-2003 Of the total investment of Rs 810,000 crore in the power sector during 11th Plan, over Rs 270,000 crore may well evaporate into an unknown space if war-footing steps are not taken to control mammoth transmission and distribution losses, an ASSOCHAM Eco Pulse (AEP) Study has found. [3]

In this research paper, the economic size of the object of investigation is considered as an important aspect regarding the selection of the wires, to study the causes of losses in transmission and distribution in wires. These losses are mainly occurs due to

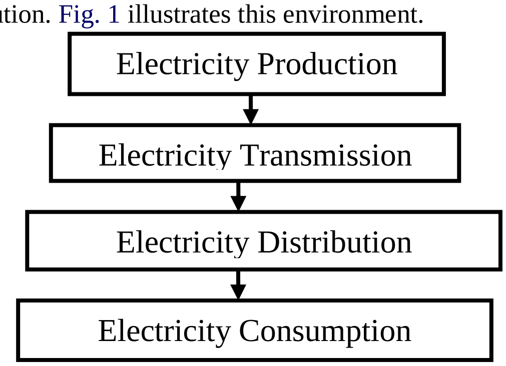
1. Copper wire resistance
2. Surface defects on wire
3. Radiation and Induction
4. Surrounding Temperature Variation
5. Impurities present in copper wire
6. Ageing
7. Proximity of electrical wire
8. Use of AC wiring in place of DC wiring or vice versa

In order to establish the cause for transmission and distribution losses in the electrical wires we have done resistance measurement of different IS and Non-IS mark electrical wire. The resistance measurement test reveals that there is about 50% more resistance in Non-IS mark wires in compare to IS mark wire. Researchers proves that there is decrease in electrical conductivity due to addition of impurities in electrical wire, and the Chemical test conducted on different wire samples clearly shows that Non-IS mark wire have high impurities in compare to IS mark wire and results about 50% less electrical conductivity in Non-IS mark wire. All the above-mentioned facts, points in this research paper to consider quality of wire for transmission and distribution losses.

The resistance measurement test at different temperature reveals that there is about 15% increase in resistance on increasing 20^0C surrounding temperature of IS mark wire and 19.7% in Non-IS mark wire. Resistance variation due to variation of surrounding temperature increases Transmission and Distribution losses.

The regulated economic environment

In the typical fully regulated environment, there is an internal supply chain. Electric utilities control the entire supply chain from production through transmission and distribution. Fig. 1 illustrates this environment.



Since costs and revenues are accumulated throughout the chain, it would be useful to practice concurrent engineering in the decision making process at each stage of chain management.1 For example, production decisions will be affected by the nature and form of the transmission and distribution facilities. Similarly, transmission decisions will be affected by production actions and distribution activities. Coordination of the various decisions intra organizationally, then, can facilitate overall system planning, management, and control. [15,16, 17]

Causes that increase transmission and distribution losses

Copper-losses[11]

(i) One type of copper loss is I^2R loss. In transmission lines the resistance of the conductors is never equal to zero .Whenever current flows through one of these conductors; some energy is dissipated in the form of heat. This heat loss is a power loss. This is one of the main causes of Transmission and distribution Losses.

(ii) Another type of copper loss is due to skin effect. When dc flows through a conductor, the movement of electrons through the conductor's cross section is uniform. The situation is somewhat different when ac is applied. Due to skin effect current in the center of the wire becomes smaller and most of the electron flow on the wire surface. The effective cross-sectional area decreases. Since resistance is

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inversely proportional to the cross-sectional area, the resistance will increase. This increases power loss in transmission system.

Losses due to surface defects on wire [10]:

1. In the case of AC, current flow on the surface of the wire. Thus surface defects effect the flow of current in wire.
2. Cracks, impression, scratches on the surface of the wire decrease strength and increase the resistance of the wire.
3. Occurrence of flaws is not completely avoidable in the processing, fabrication, or service of a material/component. Flaws may appear as cracks, voids, metallurgical inclusions, weld defects, design discontinuities, or some combination thereof. Presence of flaws reduces fracture toughness of the wire.

Radiation and Induction Losses [11]

RADIATION and INDUCTION LOSSES are similar in that both are caused by the fields surrounding the conductors. Induction losses occur when the electromagnetic field about a conductor cuts through any nearby metallic object and a current is induced in that object. As a result, power is dissipated in the object and is lost. Radiation losses occur because some magnetic lines of force about a conductor do not return to the conductor when the cycle alternates.

Techniques for reducing radiation loss:

An alternating current is made of electric charge under periodic acceleration, which causes radiation of electromagnetic waves. Energy that is radiated represents a loss. Depending on the frequency, different techniques are used to minimize the loss due to radiation.

(i) Twisted pairs : At frequencies up to about 1 GHz, wires are paired together in cabling to form a twisted pair in order to reduce losses due to electromagnetic radiation and inductive coupling. A twisted pair must be used with a balanced signaling system, where the two wires carry equal but opposite currents. The result is that each wire in the twisted pair radiates a signal that is effectively cancelled by the other wire, resulting in almost no electromagnetic radiation.

(ii) Coaxial cables : At frequencies above 1 GHz, unshielded wires of practical dimensions lose too much energy to radiation, so coaxial cables are used instead. A coaxial cable has a conductive wire inside a conductive tube. The current flowing on the inner conductor is equal and opposite to the current flowing on the inner surface of the outer tube. This causes the electromagnetic field to be completely contained within the tube, and (ideally) no energy is radiated or coupled outside the tube.

Losses due to surrounding temperature variation [12]

The general rule is "the higher in temperature the wire is, the higher the resistance to electrical flow. Due to increase in temperature greater molecular activity interferes with the smooth flow of electrons, thereby increasing resistance. Increase resistance further increase Transmission and Distribution losses.

Losses due to impurities present in copper wire [13]

The most harmful of these elements can significantly decrease electrical conductivity, increase the mechanical strength of the annealed wire, retard recrystallization, and will sometimes induce hot shortness during the hot rolling process in the production of rod.

Small amounts of alloying elements are often added to metals to improve certain characteristics of the metal. Alloying can increase or reduce the strength, hardness, electrical and thermal conductivity, corrosion resistance, or change the color of a metal (Fig 4).

Impurities used in copper wire:

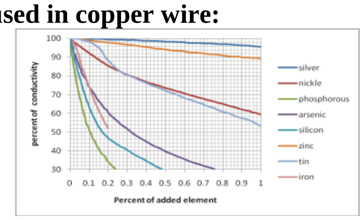

Fig 4 : Effect of impurities

(i) Nickel : Nickel is used to improve hardness and strength at elevated temperatures and to reduce the coefficient of expansion. It also provides good ductility and corrosion resistance.

(ii) Phosphorus: It is practically never found in commercial copper except for residual amounts found when it is used as a deoxidizing agent. Phosphorus lowers the electrical conductivity of copper so much that phosphorized copper is not suitable for electrical applications.

(iii) Arsenic: It is sometimes found naturally in copper in very small amounts. It slightly hardens and strengthens copper and causes considerable decreases in electrical conductivity.

(iv) Silicon: It provides good corrosion resistance with higher strength but reduces electrical conductivity of copper.

(v) Zinc: It increases the strength of copper but decreases thermal and electrical conductivity. It also increases the atmospheric corrosion resistance.

(vi) Silver: It is one of the most common impurities found in copper. Silver raises the recrystallization temperature but otherwise has no affect on its properties. In specifications it is common to count silver as copper in the analyses.

(vii) Tin: It is added to resist surface wear and can be shaped or rolled into wires. It increases ductility.

(viii) Iron: It is normally found in small amounts and does not affect the mechanical properties, but it does decrease the electrical conductivity.

Losses due to Aging[5][8]:

The aging of power, control, instrumentation, and data transmission cable is of considerable importance to, among others, industrial and electrical power plant operators in that the unanticipated failure of such cables may have significant adverse effects on plant operation and maintenance (O&M)

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costs and downtime. Like all other components, however, such cables age as the result of operational and environmental stressors. These stressors may include heat, mechanical stress, chemicals, moisture, nuclear radiation, and electrical stress.

The severity of these aging effects depends on several factors including

1. Severity of the stressor
2. The materials of construction
3. Design of the cable
4. The ambient environment surrounding the cable.

Effect of Ageing on wire

- Tensile strength of used electrical wire is reduced due to aging.
- Micro hardness &fracture toughness value decrease due to aging.
- ***Resistance of the electrical wire increases due to ageing.***
- Aging effect the mechanical as well as the physical properties of the wire.
- Aging effects only the insulation of the wire. Thus the life of wire depends upon its insulation condition.

Building wiring cost

In order that the central stations of the country may widen their fields of service, there has been an insistent demand for a cheaper system of electric wiring which would be applicable especially to already built houses, cottages, and flats of the modest type.

Optimum size of wire:

Installations in small residences invariably use more copper in the conductors than is necessary from the electrical stand point, and the high price of copper at the present time makes this item more important than it formerly was. Thus it is important to calculate optimum size of wire.

Table 1 Maximum amount of current that flows in any household applications

Appliance	Watts	Max. Current required (in amp at 220 volt)
*Room**	1000	4.7
*Central**	2000 - 5000	22
Ceiling Fan	10 - 50	0.25
Laptop	20 - 75	0.35
Desktop PC	80 - 200	1
Printer	100	0.5
Coffee Maker	800	4
Iron	1000	4.7
Incandescent bulb	100	0.47
Refrigerator/Freezer	540	2.5
Sewing Machine	100	0.47
Vacuum Cleaner	200 - 700	3.3
VCR	40	0.18
Washing Machine	500	2.4

Table 1 shows that maximum amount of current flows in any household applications is about 5 amp and minimum amount is about 0.5 amp. Thus one can use wire in houses having ampacity about 6.5 amp(considering power factor 0.8). For safety point of view 8 Ampacity wire can be used in house wiring. But at present 15 Ampacity wire are used in building wiring. Thus there is a need to find out **optimum size of wire** to reduce wiring cost.

Wire use in house wiring have same AWG (14 or 16)

Some appliance such as ceiling fan, bulb, computer, sewing machine having maximum current requirement is about 1 amp. Thus for these appliances 24 AWG wire is sufficient. This saves amount of metal used in wiring and reduce wiring cost. Thus to reduce wiring cost in houses it is important to use wire according to requirement.

AWG 20 (white)
AWG 14

Fig 6: Different gauges of wire use for different loads

Present method for reducing wiring cost

1. For reducing the cost of building wiring Chinese wire is used. In these wires large amount of impurities (such as Zinc, Cadmium, Arsenic, Phosphorus) are added to reduce the wire cost. These impurities reduce the conductivity of wire .Life of these wire is also very less and cannot be recycled. These wires are cheap solution for short period of time.
2. Aluminum wire is also used for cheap wiring.
3. Non Standard wire (wire without IS mark) to reduce cost.

Cost difference:

(i) Chinese copper 40-76 (means having 23 wire and 76 is the no.) Cost is Rs2.80 per meter
(ii) Indian copper 40-76 cost is Rs 5.20 per meter
(iii) Cost of Non standard wire is Rs 3.30 per meter

4. Cost is further reduced by supplying wire with less diameter in comparison to its specification.

Measuring the Diameter of different wire samples:

(i) Sample 1, 2, 3 diameter are according to specification.
(ii) Specified diameter of sample 4, 5, 6 is 1.38mm (or 1.5 mm^2 area) but their actual diameter is about 1.1 mm.

According to IS8130

1.5 mm^2 wire resistance = 12.1×10^{-3} ohms/m
1 mm^2 wire resistance = 18.1×10^{-3} ohms/m

In this way manufacture earn more profit by selling wire having less diameter then specify.

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Effect of present cheap wiring:

1. Increase losses (Because of high resistance)
2. Reduce wiring life
3. Increase Electricity Bill in houses means more expensive for long term use.
4. Hazardous because of large heat generation due to high resistance. This heat is sufficient to ignite a combustible material. Most of the electric accident occurs due to non-standard wiring.

Comparison of Transmission and distribution losses in Standard and Non-Standard wire

Firstly, the cost comparison [14] can be done by finding out the wattage losses (table 2) in both types of wires

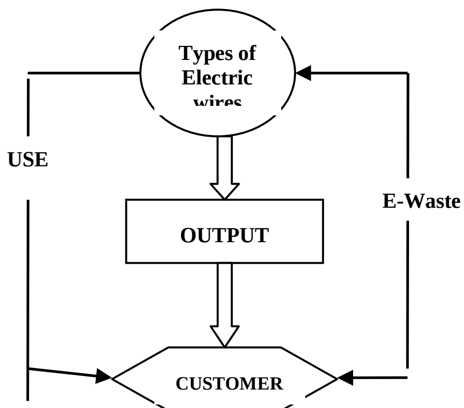

Fig7.

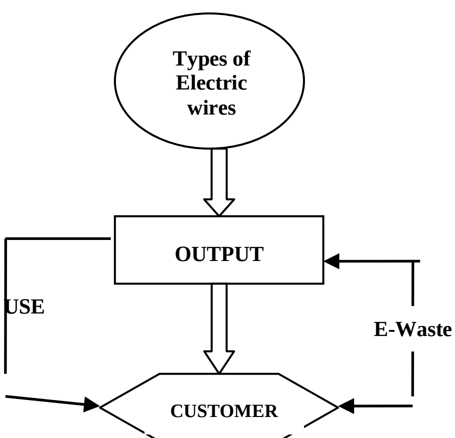

Fig 7 shows that how electric wire will affect in green supply chain management and will effect the consumption in consumer life

Table 2 shows wattage losses in appliance

Supply Voltage = 220 volt

Thus current (I) = Wattage/Voltage = 2220/220 = 10.10 amp

Loss in Quality wire (standard wire)

Resistance of quality wire = 12.90×10^{-3} ohms/m

Current = 10.10 amp

Thus loss in wire = $I^2R = (10.10)^2 \times 12.90 \times 10^{-3} = 1.316$ watt/m

Suppose length of wire used in building = 100 m Thus loss = 131.6 watt

Loss in Non Quality wire (non-standard wire)

Resistance of non quality wire = 24.64×10^{-3} ohms/m

Current = 10.10 amp

Thus loss in wire = $I^2R = (10.10)^2 \times 24.64 \times 10^{-3} = 2.514$ watt/m

Suppose length of wire used in building = 100 m Thus loss = 251.4 watt 1 unit = 1KWH

(i) Loss in Standard wire (per month) = $131.6 \times 10^{-3} \times 24 \times 30$ = 94.74 KWH =95 unit

(ii) Loss in Non Standard wire (per month) = $251.4 \times 10^{-3} \times 24 \times 30$ = 181.02 KWH = 181 unit

Increase in Transmission and Distribution losses in a month by using Non standard wire = 91%

Result & Discussion

Table 3 Resistance test on wire use in market both for IS mark and Non IS mark

The table clearly shows that the resistance of Non-IS mark is about twice the resistance of IS mark wire. Due to high resistance, Transmission and Distribution losses increase.

Table 4 shows that Non quality wire have low tensile strength because of large amount of impurities present in it

Table 5 clearly shows that resistance of wire increases on increasing Surrounding temperature. There is about 15% increase in resistance on increasing 20^0C surrounding temperature of IS mark wire and 19.7% in Non-IS mark wire. Increase of resistance further increases Transmission and Distribution losses.

Chemical Test to find out the impurities that effect electrical conductivity of wire

Table 6 (i) &Table 6 (ii)

Table 6 (i) & (ii) test results reveal that electrical conductivity decreases on adding impurities.

CONCLUSION

In this research, conclusion based on the results and discussions as shown in table 5 to 8. Since, it is not possible to cover all the aspects of any research work, so suggestions for the further study in the field of effect of aging in service, on mechanical parameters on electrical wires are also presented.

1. From the experiment results it is concluded that one of the component of transmission and distribution losses is the metallurgical impurities.
2. Ageing mainly effects wire insulation. Thus life of wire depends upon the longevity of the insulation.
3. Use of Optimum wire size can reduce wiring cost in building.
4. Heat generation in conceal wiring, Bundling of cables in conceal wiring, Conductors in conduits exposed to

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direct sunlight increases Transmission and Distribution Losses.

Future Scope

1. Metallurgical test to determine the effect of aging on wire.
2. Effect of electromagnetic environment on wire resistance and chemical composition.
3. Application of Nano material in wiring industry. Because of skin effect AC current flow on the surface of electrical wire. Thus there may be a possibility to replace copper wire or Al wire by biomaterial (thread) coated with metallic ink. The possibility of biological materials likes cotton or jute as the core for providing strength and implicating a thread of cotton dipped in metallic compound as the current conductor can be thought of.
4. The possibility of using metallic electrical conductor of a shape other then the wire produced by drawing action.
5. direct sunlight increases Transmission and Distribution Losses.

Table 2 shows wattage losses in appliance

S.no	Appliance in any building	wattage
1.	Light bulb	100
2	Ceiling fan	60
3	Refrigerator	540
4.	Tube light	40
5	Iron	800
6	Sewing machine	100
7	Washing machine	500
8	Television	80
Total		2220

Table 3 Resistance test on wire use in market both for IS mark and Non IS mark

S. N	Wire size as specified	Manufacturing company	IS8130 at 20^0C (ohms/m)	Test Resistance At room temp (33.5^0C in ohms/m)	Test Resistance (At 20^0C in ohms/m)	Wire type
1	$1.5mm^2$, 30strands, 1100V	Nilson (IS:694)	12.1×10^{-3}	12.90×10^{-3}	12.249×10^{-3}	Quality wire
2	$1.5mm^2$,22strands, 1100V	Anchor (IS:694)	12.1×10^{-3}	12.93×10^{-3}	12.278×10^{-3}	Quality wire
3	$1.5mm^2$,30strands, 1100V	Finolex (IS:694)	12.1×10^{-3}	12.97×10^{-3}	12.316×10^{-3}	Quality wire
4	$1.5mm^2$,22strands, 1100V	Rimlam PVC wire and cables	12.1×10^{-3}	27.23×10^{-3}	25.857×10^{-3}	Non Quality
5	$1.5mm^2$, 22strands,	Kaajal wire &cables Dewas	12.1×10^{-3}	29.64×10^{-3}	28.146×10^{-3}	Non Quality
6	$1.5mm^2$, 30strands,	Delhi based local company	12.1×10^{-3}	24.64×10^{-3}	23.398×10^{-3}	Non Quality

Table 4 Tensile Strength test on wire use in market both for IS mark and Non IS mark.

Sample no.	Tensile strength in Kgf
1	45.10
2	46.25
3	46.89
4	28.19
5	23.76
6	26.34

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Table 5 Conduct thermal test on wire in summer condition

Sample No.	**At room temperature(33^{0}C) In 10^{-3} ×ohms/m**	**At 20^{0}C in 10^{-3} ×ohms/m**	**At 40^{0}C in 10^{-3} ×ohms/m**	**At 60^{0}C in 10^{-3} ×ohms/m**	**At 70^{0}C in 10^{-3} ×ohms/m**
1	12.90	12.43	13.40	14.33	14.81
2	12.93	12.45	13.47	14.42	14.86
3	12.97	13.38	13.52	14.54	15.09
4	27.23	26.20	29.34	31.36	32.30
5	29.64	29.00	31.82	33.98	35.10
6	24.64	24.10	26.38	28.10	29.89

Table 6 (i) Composition of Standard wire

Component	Cu	Fe	As	Ni	Sn	Zn	Other
Wt. %	99.64	0.03	0.01	0.09	0.06	0.11	0.06
% Effect on conductivity		94.99	96.09	93.78	99.15	98.97	

Table 6 (ii) Composition of Non-Standard wire

Component	Cu	Fe	As	Ni	Sn	Zn	P	Other
Wt. %	98.59	0.04	0.01	0.18	0.16	0.93	0.02	0.07
% Effect on conductivity		91.48	96.09	86.13	95.03	89.85	83.27	

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