SPE News Letter

SPE(I), Vadodara Chapter

April, 2023 Issue: 2/2023

LET ALL POWER CUT & LOAD SHEDDING BURN AWAY FROM POWER SECTOR, (ELECTRICITY TO ALL)

ENJOY A FESTIVAL OF COLORS

Society of Power Engineers (India)
Vadodara Chapter (Estd. 1996)

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FROM THE CHAIRMAN'S DESK

Dear Readers,

The year 2023 started with the World's largest exhibition in the power industry, ELECRAMA-2023, which was held between 18 & 22 Feb 23 at India Expo Mart, Noida. This was the 15th edition of the world-class exhibition and was inaugurated by **Shri RK Singh**, Hon'ble Minister of Power and New & Renewable Energy. ELECRAMA is held once every two years and is the exhibition for power, electrical, and industrial electronics and allied products, organized by IEEMA that covers the entire spectrum of electricity.

In his inaugural address, the minister appreciated India's renewable energy journey which has brought great transformational changes in the industry in the past five years. He praised IEEMA for focusing on the energy transition and future technology through this exhibition which is in line with the government's '**Vision for India @2047**'and our commitments towards being climate friendly.

You may be aware that the Indian Electrical & Electronics Manufacturers' Association (IEEMA), is the apex industry association of manufacturers of electrical, industrial electronics, and allied equipment in India. IEEMA has around 800 member organizations encompassing the complete value chain in power generation, transmission, and distribution equipment. With more than 1,000 exhibitors from over 75 countries showcasing their products, latest technologies, and services, ELECRAMA-2023 provided a platform for the electrical and power industry to network and connect with potential buyers, suppliers, and partners all over the World. The exhibition witnessed a massive 3.5 Lac footfalls of visitors from across the globe.

The theme of the exhibition was appropriately selected as "Re-imagining the energy for a Sustainable Future" which demonstrates how India's power sector has changed. It showcases innovation and future technologies in a vast area namely Power Generation, T & D, Renewables, Electric Transportation, Power Storage, Electrical Automation/Power Electronics, Green Hydrogen, Fuel Cells, decarbonization, net-zero, AI, IoT, and many others. Apart from the display of products and various technologies, the exhibition also featured several technical conclaves and industry summits such as World Utility Summit, ETechnxt, and BuildElec etc. The topics such as the need for quality of the product for the ever-growing electric sector, innovation and emerging technologies, sustainability via energy conservation, new business opportunities, supply chains, and start-up ecosystems were discussed. The Reverse Buyers Sellers Meet (RBSM) and Domestic Buyers Sellers Meet (DBSM) with several planned meetings, were found very beneficial for the exhibitors and the buyers. The electrification of railways, industries, offices, and homes was also discussed during this mega event.

The ELECRAMA-2023 exhibition has showcased to the world the potential and leadership capabilities of Indian manufacturers to offer globally competitive products using modern technology. Our engineers have made a great deal of contribution to this sector. We are sure that in the coming decade, the industry will be adopting numerous innovative and tech-enabled solutions for a sustainable future.

Best wishes to the readers.

GV Akre

EDITORIAL

COMPETITION

Dear Readers,

In the World of business, competition is not much liked. Everyone wants to monopolize his business. As a matter of fact, business and competition are the root causes of many wars all over the World. However, if a thorough introspection is done, it can be concluded that competition is a real growth engine. It is a common understanding that it is difficult to reach on the top but it is extremely difficult to remain on top. Monopolistic business attitude helps the business to survive but the element of competition makes the growth sustainable. For many years, some brands of tooth pastes, bathing soap and detergent powders had practically no competitions and therefore those manufacturers never bothered to usher into the experiments. Same thing is true for service sectors like Telecom, Power, Ports, Broadcasting, Banking, Posts, Aviation etc. They were owned and supported by the Governments and therefore they had monopolized their activities. Competition in these sectors have helped the PSUs to revisit their strategies.

The Door-Darshan and Akashvani are the best examples of transformation due to competition. The Banking sector has changed drastically. I remember 80s and 90s when getting a loan from a bank was like a nightmare and these days we are tired of phone calls for receiving loans. This transition is possible only because of the element of competition. The law of jungle "Survival of fittest of fit" is now very much applicable to the business. When the successive Governments in India in 80s and 90s opened the doors for international trade and technology, there was a section in the country which opposed this move on the pretext of invasion by international vested interests. With the passage of time this apprehension has proved to be wrong. Today we are at such a pass that whole World is staring at the economy of our country. Most of the developing and some of the developed countries are eager to have cordial business relations with our country.

This has become possible only due to an element of competition. The competition in Power Sector coupled with reforms has given a booster doze to the economy. Import of technology and "Make in India" initiative has improved the availability and quality of power supply. The successive Governments in the country in 21st Century have realized that development and sustenance of economy mainly depend upon the development of power sector. The model of Public-Private-Partnership (PPP) deployed in Power Sector has boosted power sector beyond imagination. The PPP model in power transmission sector has removed the congestion in network and has paved a way for evacuation and best utilization of RE power and fulfill the mission of Government for power (electricity) to all. The load shedding has become a history now. Again an element of competition between national and international agencies has helped in fast and sustainable growth of power sector and GDP.

Competition among various states of India to perform better and better has helped the population at large. Infrastructure development has also gathered pace due to the presence of international agencies.

Another live and latest example of gain of competition is a performance of our players in international events. Preparedness to face competitive challenge by our sports persons has started bringing glory to the country. Similarly our defense equipment have also started shining at international level.

When you grow, the competition also grows. Facing the competition means keeping you and your organization always fit to take challenges. The competition in technology has helped the common man in availing services and equipment at lower rates. On the other hand it is creating threats also, but it is like a coin having two sides.

Talking about the Vadodara Chapter of SPE (I), there is a good and healthy competition during the annual election and also again to be an office bearer or the Advisory Committee members. This is a good sign for the sustainable growth of the Chapter of SPE (I) Vadodara.

Best wishes to the readers.

SM Takalkar

CHAPTER'S ACTIVITIES

➢ On **25 Feb 2022** the **Chapter** organized an evening lecture session at Vasvik Auditorium, the IE (I). The subject was **"Energy Transition"** and speaker was **Er. Sushil Kumar Sharma**, Founder CEO, Sustaineco and former GM (Corporate Sustainable Development), NTPC.

In his lecture he covered the following:

- ❖ Need to harness Green Energy in different forms
- ❖ Energy Transition Pathways & Performance Index /Efficiency Index
- ❖ 5 commitments of India and our Hon'ble PM Shri Narendra Modi to the World community related to reduction in dependence fossil levels, reduction of Carbon foot prints etc.
- ❖ Reduction in %age T&D losses.
- ❖ Energy transmission index.
- ❖ Means to reduce pollution
- ❖ Concern of increase in Global temperature

The lecture was attended by about 100 members. The programme was arranged jointly by SPE(I) Vadodara and IE(I) Vadodara. The lecture was appreciated by the engineers present in the hall.

In the beginning the speaker was introduced br **Er. PA Shah**, AC Member, SPE(I) Vadodara. Er. **Ambikesh Padhya**, Chairman, IE(I), Vadodara gave welcome speech.

The vote of thanks was presented by **Er. YV Joshi**, Secretary, SPE(I) Vadodara.

➢ On **26 Mar 2023, Chapter** organized a Lecture session on "**Musical Therapy**". The lecturer was **Dr. Archana Nanoty**, Professor of Electrical Engineering, Navsari College and Life Member of SPE(I) Vadodara. In her presentation, she produced clips of various sounds and took feedback from the audience regarding their reaction to the sounds. She mentioned that it is now an established fact that Music can cure many ailments as they are mostly caused due to mental stress. The programme was attended by members and their spouse which was organized in Baroda High School, Alkapuri.

This programme was the "**Concluding Event of the Silver Jubilee Celebration**" of the Vadodara Chapter founded on **03 Oct 1996**. Before the scheduled lecture on **Musical Therapy**, **Er. PA Shah** invited **Er. GV Akre**, **Er. PH Rana**, **Er. SM Takalkar**, **Er. YV Joshi**, **Er. RS Shah** and **Er. NG Yadav** on the dais and requested them to speak on the occasion. **Er. Akre** welcomed all the members and their spouse. He went on to indicate the roles played various engineers in shaping the Chapter. **Er. Rana** described various events organised by SPE under his leadership during Silver Jubilee celebration year. **Er. Takalkar** recalled all the events which took place before the formation of the Chapter and those took place during last 25 years. **Er. Joshi** & **Er. Shah** also expressed their views on the Chapter's journey. Er. Yadav gave the details of major contribution received for Silver Jubilee. **Er. Takalkar** was greeted by the members on completion of 75 years of his life. The programme was well organised by **Er. PA Shah, Er. Parag Parmar** and **Er. YV Joshi**.

Er. YV Joshi
Secretary

MEMBERS IN NEWS

Dr. Archana Nanoty, Life Member of SPE(I) Vadodara Chapter, has been conferred with **A+ Grade** in Govt. of India Certification on **"Advanced Music Therapy".**

Congratulations to Dr. Nanoty.

The CBI&P, jointly with International Association on Electricity Generation, Transmission & Distribution (Afro Asia Region), had organized a National Workshop on **"Energy Management Ener4gy Conservation and Energy Audit"** on 09 & 10 Feb 2023 at New Delhi.

During the opening session, a Certificate of appreciation was presented to **Dr. Shivani Sharma**, Principal Technical Consultant, Power Consulting, Hitachi Energy, by the dignitaries on the dais for her long-standing contribution to the work related to the dissemination of knowledge for development of Power & RE Sector.

There were 6 Technical Sessions conducted over 2 days. All the presentations were focused, suitably technical and to the point. Further, clarity was enabled by the Q & A opportunity in each session. Following Life Members of SPE (I) Vadodara Chapter presented technical papers.

Er. BN Raval, Retd. Chief Engineer, GETCO, Director-Soham Technologies and Advisory Committee & Life Member of SPE(I) Vadodara Chapter, addressing the participants.

Er. PA Shah, Retd. Chief Engineer-GETCO, Practicing Electrical Engineer and Advisory Committee & Life Member of SPE(I) Vadodara Chapter making his presentation.

Er. HR Karandikar, former Director-ERDA, Consultant and Patron & Life Member of SPE(I) Vadodara Chapter, making his presentation.

Dr. Shivani Sharma, Principal Technical Consultant, Power Consulting, Hitachi Energy and Patron & Life Member of SPE(I) Vadodara Chapter making, her presentation.

ROLE OF CONDUCTOR METALLURGY IN EHV TRANSMISSION LINE DESIGN

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1. INTRODUCTION

1.1. Conductor is the most important and cost intensive component of EXTRA HIGH VOLTAGE (EHV) Transmission lines. Design of other components of line also much depend on the conductor metallurgy and physical properties.

1.2. In yesteryears the most popular conductors for transmission lines were Aluminium Conductor Steel Reinforced (ACSR) & All Aluminium Alloy Conductor (AAAC). They were used to transfer certain fixed amount of power based on the ambient temperature and depending upon their metallurgical and mechanical parameters. With the change in time the emphasis is on transfer of large quantum of power per unit cost of Right of Way (ROW). Thus, the new generation conductors are designed with lot many new metallurgical features.

1.3 The important metallurgical parameters of the conductor which affect the design, are as follows

- Conductivity and resistance (R)
- Co-efficient of Linear expansion (α)
- Modules of elasticity (E)
- Density of conductor (δ)
- Ductility & Creep

1.4 The important mechanical para-meters which affect the design are as follows

- Weight per meter
- Overall diameter
- Cross–sectional area
- Normal span for design

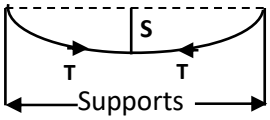
1.5 The important parameters which affect the electrical design of the conductor are as follows:

- Skin effect
- Corona
- Inductance (only in AC power flow)
- Capacitance (only in AC power flow)

2. SAG & TENSION CALCULATIONS

2.1 In order to design the transmission line supports (Towers, Poles etc.) Sag & Tension calculations have to be done as the height of the support is decided by the Sag and strength of support is decided by the tension.

2.2 The basic equation for calculation of Sag is as under:



Where S = Sag in metres

$$S = \frac{WL^2}{8T}$$

L = span in metres

T=Tension in kG.

2.3 In the above equation the variable factor is Tension (**T**). It is worth noting that the value of **T** will increase with the increase in wind pressure and value of (T) will decrease with the increase in temperature (**t**). The value of **t** is the sum of the ambient temperature t_1 and the net tempe-rature gained by the conductor due to the passage of current t_2. Thus $t = t_1 + t_2$. Again, t_2 is the product of I^2R where **I** is the current flowing through the conductor and **R** is the resistance of the conductor. The value of **R** for the passage of Direct Current (DC) is slightly less than that for the passage of Alternating current (AC) due to the effect of frequency.

2.4 The current carrying capacity of conductor depends mainly on heat balance equation as follows:

$P_j + P_{sol} = P_{rad} + P_{conv}$

Where P_j – heat generated by Joule Effect

Where P_{sol} – heat generated due to solar

Where P_{rad} – Radiation heat loss of conductor

Where P_{con} – Convection heat loss of conductor

The above equation clearly indicates that the heat generated due to passage of current through the conductor plus the heat gained from atmosphere has to be balanced by the sum of heat radiated in atmosphere and the

heat convection by the metal of the conductor.

2.5 The above equation clearly indicates that the conductor can handle more amount of current if the allowable temperature is raised. The conventional ACSR conductor can be loaded till the conductor surface temperature reaches to 90°C. After this temperature annealing of Aluminium will start and therefore the entire tension will be taken by steel core. This is termed as the "knee point temperature". This is not desirable for the mechanical performance of the conductor.

2.6 Typical calculations for Ampacity of ACSR "Moose" and ACSR "Zebra" conductors, based on the heat balance equation indicated above, are given here under:

$P_j + P_{sol} = P_{rad} + P_{con}$

Thus $P_j = P_{rad} + P_{con} - P_{sol}$

Now $P_j = I^2R$ where I is the current and R is the AC resistance of conductor

Therefore, $I^2R = P_{rad} + P_{con} - P_{sol}$

Thus $I = \sqrt{\frac{P_{rad} + P_{con} - P_{sol}}{R}}$

The calculations are done with an assumed Ambient as 40°C and surface temperature of electrically loaded conductors as 75°C.

The value of AC resistance R at 75°C for the conductors are as under:

ACSR "Moose" 0.07011 x 10^{-3} Ohm/M.

ACSR "Zebra" 0.0867298 x 10^{-3} Ohm/M

Prad = Radial heat loss in watts per metre of conductor at 40^0C

The values of P_{rad} for the conductors are under:

ACSR "Moose" 6.4073736 Watts/M

ACSR "Zebra" 5.7720816 Watts/M

Above value are obtained by the product of 2.0168 x D where D is the diameter of conductor.

P_{con} = Convection heat loss of conductor in Watts per linear meter of conductor length at 40^0C

The values of P_{con} for conductors are as under:

ACSR "Moose" 24.796623 Watts/M

ACSR "Zebra" 23.51297 Watts/M

The above values are obtained by the equation+ as follows:

0.47588 + 13.333 $D^{0.52}$ Where D is the diameter of conductor in cm.

P_{sol} = Heat gained from Sun in Watts /M length of the conductor

The values for the conductor are as follows:

ACSR "Moose" 1.14372 Watts/M

ACSR "Zebra" 1.03032 Watts/M

These values are derived by the product of 3xD where D is the diameter of the conductor.

Substituting the values of P_{rad}, P_{con} and P_{sol} in the equation we can obtain the Ampacity I as follow:

ACSR "Moose" conductor

$$I = \sqrt{\frac{6.407373 + 24.796623 - 1.14373}{0.07011 \times 10^{-3}}}$$

$= 654$ Amp

ACSR "Zebra" conductor

$$I = \sqrt{\frac{5.7720816 + 23.511297 - 1.03032}{0.0867298 \times 10^{-3}}}$$

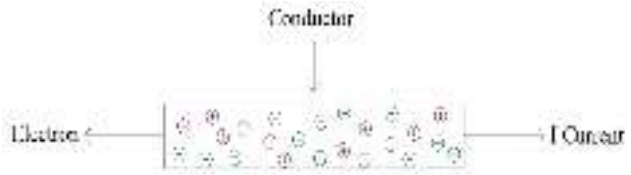
$= 570$ Amp

2.7 The Ampacity will depend upon the metallurgy, ambient temperature and emissivity. Thus, every type of conductor will have different Ampacity.

3. EFFECT OF METALLURGICAL PARAMETERS

3.1. The metallurgical parameters influence the performance of conductor in different manner. They are discussed here under

3.1.1 Conductivity and resistance are opposite to each other. Conductivity depends upon the free electrons available in the molecular structure of the metal. Conductivity also depends upon the speed of the travel of electrons in the metal. Copper has a better conductivity and less resistance compared to Aluminium.



However, due to high cost and problems of theft, Aluminium conductors are being used in overhead transmission for last more than 50 years. Contrary to this the motors and transformer winding are made up of Copper coils only. This is for

the fact that Aluminium has higher resistance and may damage the insulation due to heating. There are transformers (Distribution transformers) which have Aluminium winding. Majority of control cables are of copper. Power cables can be Aluminium or Copper depending upon the end use and method to dissipate the heat.

3.1.2 The co-efficient of linear expansion (α) for the conductor is another important factor. It is defined as the increase in length per unit original length per degree rise in temperature. This is a type of temperature stress. In transmission line, the conductor is clamped on each tower and therefore, the increase in surface temperature results into increase in the catenary length and the sag. Similarly decrease in surface temperature results in decrease in the catenary length and the sag. Thus, the value of (α) is responsible for variations in sag with the variation in temperature. α is obtained from the type test of the conductor.

3.1.3 In case of ACSR conductor, the values of resistance (R) & coefficient of linear expansion (α) are for the composite cross section covering Steel & Aluminium strands. However, in reality the value of R and α are different for Steel and the Aluminium strands. Depending upon the size of each strand and total number of strands of Steel core and the Aluminium layers, different types of ACSR conductors will have different value of R & α and the knee point temperatures. However, as a thumb rule, the ACSR conductor should be electrically loaded only up to a temperature of 90^0C (which includes ambient of 45^0C). This is covered above.

3.1.4 The conductors made out of Aluminium alloy as well as with annealing can be operated at higher temperature (beyond 90^0C) without any change in metallurgical performance. Change in core material or special coating to the Steel material, can allow passage of more current due to high temperature operations.

3.1.5 The modulus of Elasticity (E) is one of the most important parameters which determines the conductor behaviour under varied climatic conditions imposed upon the conductor during its life span.

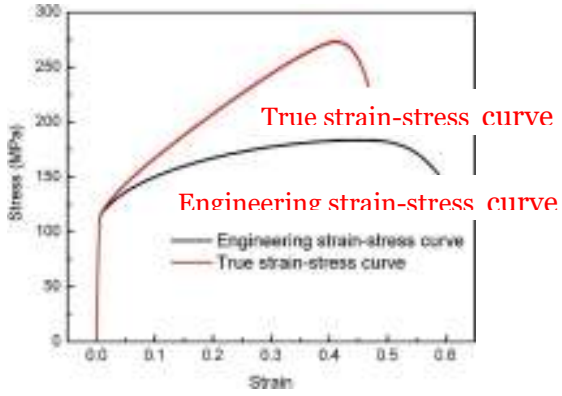
$$E = \frac{\text{Stress}}{\text{Strain}}$$

again

$$\text{Stress} = \frac{\text{Load (Tension)}}{\text{Area of Cross Section}}$$

$$\text{and Strain} = \frac{\delta L}{L}$$

Where δL is the increment in length of conductor under tension &
L= length of conductor put to the test. Stress–strain curves of each type of conductor is a reflection of conductor behaviour within the yield limits.

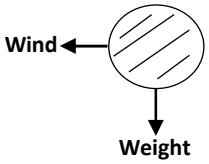


Typical stress-strain curve

3.1.6 The density of conductor is important for calculation of Sag & Tension at varying temperatures and wind pressures.

$$\text{Density} = \frac{\text{Unit weight of conductor}}{\text{Cross–sectional area of conductor}}$$

This parameter helps in working out resultant force on the conductor and ultimately the Tension and Sag at various wind velocity & pressure while in service



3.1.7 Ductility and creep are other parameters. The value of stress, strain & E depends upon ductility and creep

(which is a permanent elongation). The initial creep of the conductor is due to assumption of initial Sag & Tension when the conductor is unwound from drums and is laid on the towers. The creep which occurs over a period of time is due to cyclic thermal stresses imposed on the conductor.

A typical set of calculations for creep over a period of time is given here under:

The Creep Calculation For AAAC Conductor is Done Using Following Equation.

$e = 0.01165\ (t)^{0.2} \times (1.434 - W_a)\ (P_a)^{1.115}\ (106.58\ Q_a)$

Where, e = Creep in mm/kM

W_a = (Unit weight of steel core)/(Unit weight of conductor)

t = Time in hour for 20 years

= 24 x 365 x 20 = 1,75,200 Hrs.

P_a = Everyday tension in percentage of UTS

Q_a = Everyday temperature 32^0C

Data for Creep Calculations		
	Units	Values
Weight of steel core	kG/kM	0
Weight of conductor	kG/kM	1255.41
3 Day time	Hours	72
365 Day time	Hours	720
20 Year time	Hours	8760
Watt	Hours	175200

Creep (e) = $0.01165\ (175200)^{0.2} \times (1.434 - 0)\ (25)^{1.115}\ (106.58 + 32)$

= **1049.333 mm/kM**

Final Tabulation of Creep Over Period of Time					
Q_c Temp. (C)	P_a (%)	Creep of AAAC Conductor (mm/kM)			
		for 3 days	for 30 days	for 365 days	for 20 Years
32	25	178.564	349.682	547.264	1049.333

Above table indicates that the creep in conductor is a very slow process.

3.1.8 The ductility test is required to be done only on the current carrying strands of ACSR conductor. As per IS–398 the relative ductility can be established by Torsion test or elongation test. The wrapping test is performed to find the strength of Aluminium & steel cores against the fatigue stress. This can also be viewed as brittleness index of a strand of the conductor.

4. EFFECT OF MECHANICAL PARAMETERS

4.1 The effect of mechanical parameter on the behaviour of transmission line conductors are described here under

4.1.1 The unit weight of conductor has a direct effect on the Sag & Tension. It causes vertical load on the tower. Higher weight reduces the swing of the conductor in midspan but wind force increases.

4.1.2 Overall diameter of the conductor attracts wind force when it is strung on the towers. The drum on which the conductor is wound is sized considering the diameter and unit weight of the conductor. The hardware fittings also depend upon the diameter of the conductor.

4.1.3 Cross–sectional area of the conductor has a direct relation with the current carrying capacity. Cross–sectional area is also responsible for carrying the stress due to the Tension of the conductor. While working out Sag & Tension at different temperatures and wind pressure, the estimation of stress is very important.

Basic Equations

We have,

$G = L^2\ \delta^2\ q^2\ E / 24$ ..... (1)

Where,

G = variable operator

E = Modulus of elasticity

δ = Density of conductor = w/A (kG /M/M²)

w = Weight of conductor per metre

A = Area of conductor M²

$(q)^2 = 1 + (p / w)^2$;

(q = Resultant load)

p = Wind Force (kG) = (P X D)

where

D = Diameter & P = Wind Pressure

Further,

Also, $G = f^2 \{f – (k – \alpha tE)\}$... (2)

Where,

f = Stress on conductor (kG/M^2),

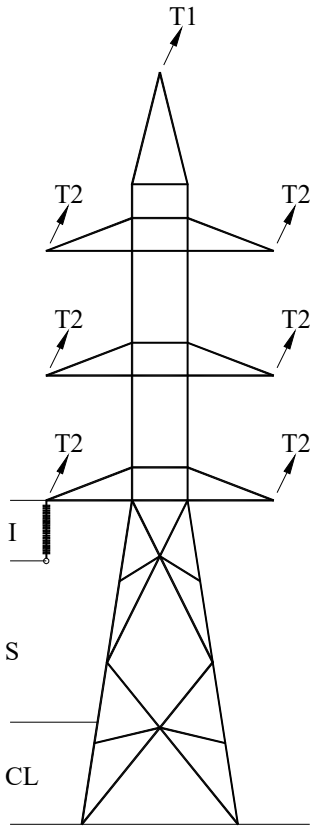
k = Constant, t = Temperature (°C)

and α = coefficient of Linear Expansion of the Conductor.

The value of sag, tension and factor of safety (FOS) are worked out for three wind conditions and three temperatures. The wind pressure is different for each of six wind zones of the country. The wind conditions are 0% wind, 36% wind and 100% wind. The three temperatures are minimum temperature (0°C), everyday temperature (32^0C) and maximum temperature of conductor with the ambient is equal to 45^0C. Normally maximum temperature is 75^0C to 85^0C.

For calculating the sag, tension and FOS, starting condition is 32^0C temperature and 0% wind FOS = 4. UTS / FOS gives value of working stress **f**. Substituting value of **f** in the equation $G = L^2 \delta^2 q^2 E / 24 = f^2 \{f – (k – \alpha tE)$, we can find out a value of **k**. This value of **k** is common for all wind pressures and all temperatures. Thus, we can obtain value of stress **f** for any combination of wind and temperature. Further **f** x A = tension (**T**) where A = Cross sectional area of the conductor. Now sag (**S**) = $WL^2 / 8T$ and FOS = UTS/T. Therefore, we can find out sag, tension and FOS for all the wind pressures and all the temperatures.

4.1.4 The sag and tension calculations help in designing the line supports (towers). The sag at 0% wind (no wind) and maximum temperature will be maximum. The bottom cross arm of tower shall be at an appropriate height to take care of this maximum sag. The tension at 36% wind and 0^0C temperature or 100% wind at 32^0 C temperature, whichever is higher, shall be considered for the strength of tower as show below:



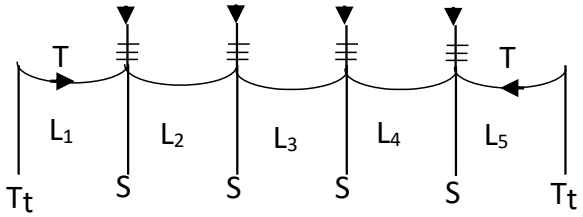
Where
I = Insulator String length (Fixed)
S = Maximum Sag
CL = Clearance above ground (Fixed)
T_1 = Tension of ground wire
T_2 = Tension of conductor

Thus, the sag-tension calculation helps in designing the support (tower) structures.

4.1.5 Ruling span is very important for working out Sag & Tensions at different wind pressure and different temperature. There are different types of spans in design of transmission lines support, which are as under

- Normal Span–This is considered for design of support with reference to Sag & Tension.
- Wind Span–This is considered to take the effect of wind on conductor. It is normally 1.1 times the normal span.
- Weight Span–This is considered for the maximum weight of the conductor over longer tower spotting. It is normally1.5 to 2.0 times the normal span based on the reliability requirement of the tower and the line.

- Equivalent Span–This is a fictitious span considered for preparing the stringing charts between two tension locations.



T_t= Tension Tower, S=Suspension Tower, L_1/L_2 etc. are the spans, T is a tension of conductor.

The equivalent span is worked out using following equation.

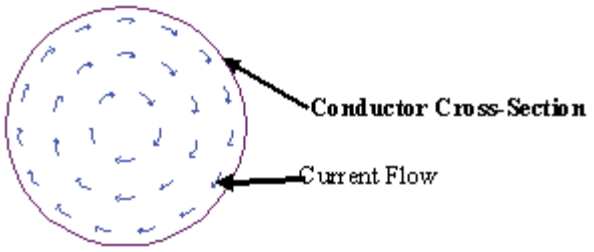
$$L_{eq} = \sqrt{\frac{L_1^3+L_2^3+L_3^3+L_4^3+L_5^3}{L_1+L_2+L_3+L_{14}+L_5}}$$

It is pertinent to note that the tension of conductor between two tension towers will be common for all the spans whereas the sag in individual span will be worked out on the basis of individual span.

5. EFFECT OF ELECTRICAL PARAMETERS ON THE CONDUCTORS AND LINE

5.1 The effect of electrical parameters on the conductor and line design are described below

5.1.1 Skin Effect–The tendency of the current to flow through the outer periphery is called a 'Skin Effect'. This is for the simple reason that in the outer periphery the area of conductor is larger and current always tries to take a path of least resistance.



The stranded conductors help in reducing the skin effect as the diameter of individual strand is very less and there is practically no scope for skin effect. Stranding of the conductor also helps in providing flexibility in the conductor for winding on the drum and in stringing.

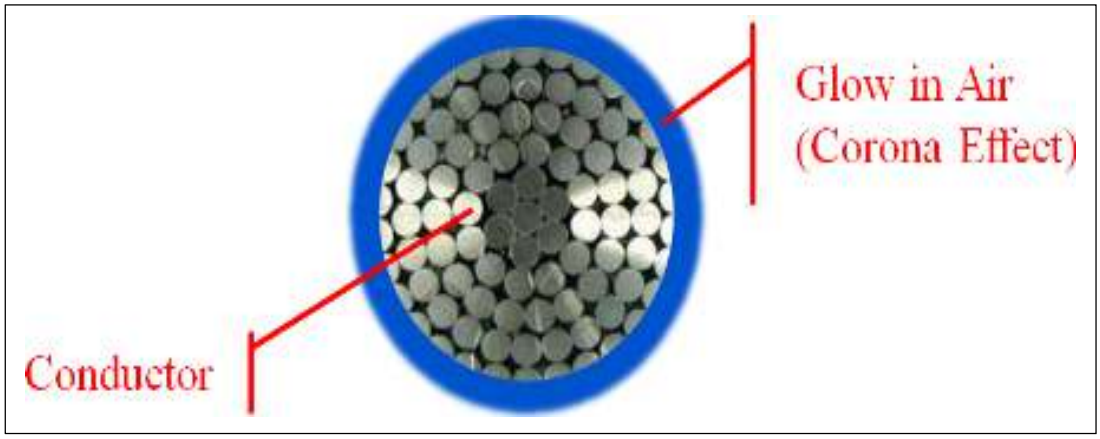
5.1.2 While carrying current at Extra High Voltage (EHV), the conductor has a tendency to ionize the surrounding air.

When the humidity is maximum the process of ionization of air becomes much significant. This phenomenon is called "Corona". Due to the corona the conductor surface is affected. New conductor surface experience less corona. As the conductor ages the corona becomes predominant.

The inception of corona is as a violate glow all along the conductor length. Corona is associated with hissing noise as well as production of Ozone gas.

Just before monsoon when the humidity is at its peak, the Corona becomes visible

The conductors used for voltages above 220kV are also tested for corona.



The power loss due to corona is calculated by the formula

$P = 242.2 (f+25) \sqrt{r} (v-v_c)2 \times 10^{-5}$ kW/kM/phase

$\delta \quad d$

Where, f = supply frequency in Hz.

V = phase-neutral voltage (rms)

Vc = disruptive voltage (rms) per phase

= mogo δ r log d kV/phase

Where,

mo = 1 for polished conductors.

= 0.98 to 0.92 for dirty conductor.

= 0.87 to 0.8 for stranded conductor

5.1.3 The inductance L of the conductor results into an inductive reactance which is worked out by an equation as follows:

$X_L = 2\pi fL$

where X_L is inductive reactance in Ohms,

f = frequency in Hz &

L= Inductance in Henri

The inductive reactance causes reduction in power factor cosϕ

5.1.4 The capacitance C of the conductor results into a capacitive reactance which is worked out by an equation as follows:

$$X_c = \frac{1}{2\pi fc}$$

Where X_c = Capacitive reactance in Ohms

f = frequency in Hz

c = capacitance in Farad

The capacitive reactance causes increase in power factor cosϕ

6. NEW CENERATION CONDUCTORS

6.1 Due to the limitations of operations up to 90^0C, the ACSR conductors are now being replaced by new generation conductors which operate at the temperatures beyond 90^0C and even up to 250^0C. This is possible only because of metallurgical changes in the structure of the conductors. They include Trapezoid shaping of Aluminium strands, Annealing of Aluminium strands, Aluminium cladding of steel core, use of INVAR core, use of carbon core etc.

6.2 The New generation conductors include the following

- Aluminium Alloy Conductor Steel Reinforced (AACSR)
- Aluminium Conductor Alloy
- Reinforced (ACAR)
- Trapezoidal Aluminium Strands with Steel Core (TASC)
- Thermal resistant Aluminium Alloy Conductor Steel Reinforced (TACSR)
- Aluminium Conductor Steel Supported (ACSS)
- Gap type Thermal resistant Aluminium conductor with Steel Reinforcement (GZTACSR)
- Super Thermal Alloy conductor with INVAR reinforcement (STACIR)
- Aluminium Conductor Composite Core (ACCC)

6.3 New generation conductors find good application for new lines and for up–rating (increasing Ampacity) and or up-gradation (increasing Voltage Level) of existing lines. The ACCC and ACSS conductors are much suitable for up–rating and or up-gradation of existing transmission network. The other type of New Generation Conductors finds their place in New Transmission Lines, this includes evacuation lines for solar/wind power and also from super thermal power stations.

6.4 The table below gives comparison of mechanical, electrical and thermal capabilities of various conductors. It can be seen that the new generation conductors can operate at very high temperatures.

Technical Comparison for ACSR Zebra & its equivalent Conductors - WIND ZONE 4

Type of Cond.	Cross Sect. Area (mm^2)	Con. Dia. (mm)	Modulus Of Elasticity (kg/cm^2)	Co-eff. of Linear Exp. ($/^0C$)	Weight (kg /km)	UTS (kgf)	AC Ress. ohms/km	Max. Temp. (°C)	Volt Level (kV)	Current carrying capacity	Sag at Maximum Operating Temp. (°C) & 0% wind	Tension at 32 °C & 100% wind	Revenue generated in INR 4/unit
ACSR Zebra	484.50	28.62	725500.00	$19.4*10^{-6}$	1621.00	13283.38	0.08479	75	220	562.33	9.26	8052.54	6199276800
TACSR	467.00	28.62	725500.00	$11.5*10^{-6}$	1621.00	14290.52	0.08668	150	220	1241.18	10.20	8050.29	13648220160
STACIR	446.63	27.60	713557 & 1580020.38	$16*10^{-6}$ & $3.7*10^{-6}$	1616.00	14290.52	0.09594	210	220	1454.41	8.89	8054.79	15982900320
ACSS (ZEBRA)	484.50	28.62	702344 & 2110091.74	$18*10^{-6}$ & $11.5*10^{-6}$	1621.00	13221.20	0.08051	210	220	1660.90	11.95	8053.46	18257416800

ACCC Hamburg	613.80	28.62	1179408.76 & 636085.6269	$1.61*10^{-6}$ & $19.1*10^{-6}$	1646.40	16442.41	0.06360	175	220	1602.63	9.76	8054.04	17602273920
ECO	583.02	28.62	662589.19	$23*10^{-6}$	1608.00	13781.86	0.06309	95	220	952.50	10.75	8051.74	10470477600
ACCC Kolkata	630.69	28.62	1144750.25 & 655453.61	$1.61*10^{-6}$ & $18.7*10^{-6}$	1606.00	17614.68	0.06629	175	220	1570.43	9.84	8052.59	17251873920
GAP	567.5	29	2098878.69 & 758409.75	$20.2*10^{-6}$ & $11.5*10^{-6}$	1856	15586.14	0.07012	210	220	1718.82	12.77	8049.82	18890239200
ACSS-TW	588.5	28.62	717227.31 & 2089704.38	$19.46*10^{-6}$ & $9.1*10^{-6}$	1893	10499.49	0.08051	210	220	1600.90	11.90	8054.27	17594039520
AL-59 (61/3.18)	484.5	28.62	560843.92	$23*10^{-6}$	1704	12368.00	0.07534	95	220	874.41	9.73	8051.44	9629517600
AAAC (61/3.19)	488	28.7	693100.00	$23*10^{-6}$	1345	13663.61	0.08498	95	220	826.02	10.03	8054.83	9103917600
ACCR	484	28.6	1193068.00	$16.5*10^{-6}$ & $6.3*10^{-6}$	1357.6	14323.30	0.08112	210	220	1594.62	11.45	5128.75	17523959520

Note: The values of modulas of electicity indicated in column 4 for STACIR, ACSS, ACCC, GAP and ACCR conductors are respectively for below and above knee point temperatures.

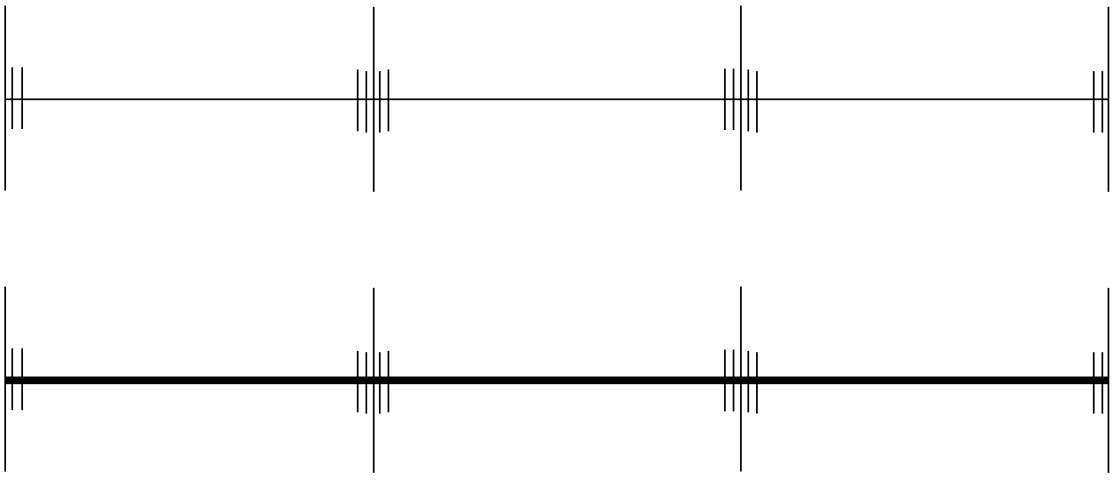
7. CASE STUDIES

1. 66kV line updated to 132kV for Torrent Power Ahmadabad

As a part of up-gradation of existing power system Torrent Power Ahmedabad decided to convert one of the two double circuit lines from 66kV to 132kV from Naroda substation to Nicol substation. The line was upgraded to 132kV and replacement of ACSR Dog conductor to ACCC Casablanca conductor. The 66kV D/C line which was carrying 260Amp is now able to carry 1050 Amp. The tower on the right side is 66kV D/C and one on the left is tower modified from 66kV D/C to 132kV D/C. This is possible only due to the metallurgical changes in the design of conductors.

2. 220kV Borivali substation change in ampacity of existing Bus

In Borivali 220kV substation the existing bus was having twin ACSR Moose conductor. The capacity of this Bus was 1500Amps (750Amps/Conductor). Due to installation of GIS equipment the capacity of the Bus needed to be augmented to 3000Amps. Using Quad ACSR moose conductor would mean change in the existing structures and gantry column foundations. Since the substation in north Mumbai cannot afford longer shut-downs, various options were tried out and ultimately it was decided to use twin ACSS Curlew conductor which delivers 3200Amps (1600Amps per conductor) at 160^0C.



The ACSS Curlew Conductor has same mechanical properties that of the ACSR moose conductor and therefore no change in structure and foundation was required. The entire work was completed within couple of short duration shutdown.

8. CONCLUSION

8.1 The metallurgical, mechanical and electrical parameters of conductor has a big influence on the electrical and mechanical design of EHV transmission lines.

8.2 The changes of metallurgical structure of the transmission line conductor have a large influence on the electrical & structural design of the line and also on the performance of line.

About the Author:

Er. SM Takalkar

Graduated in Electrical Engineering from MS University, Vadodara in 1971. He joined Gujarat Electricity Board in 1972 as a Junior Engineering and retired as a Chief Engineer (Transmission) in 2006. During his tenure of 34 years he worked in Distribution, Generation and Transmission Department. Most of his tenure was in Transmission department. He is a member of Bureau of Indian Standards (BIS) and Central Board of Irrigation and Power (CBIP) for Transmission line and Substation related committees.

He has received several Awards for R&D and contribution to the Transmission Segment. At present he is a Managing Director of M/s Takalkar Power Engineers and Consultants Pvt. Ltd., Vadodara. The firm is offering services of Electrical, Civil & Structural Engineering Designs, Energy Management, Project Monitoring and Energy Audit.

Mobile: 99252 33951, 98795 99402

..... AN INITIATIVE BY VADODARA CHAPTER OF SPE (I) FOR DEVELOPMENT OF ENGINEERING STUDENTS IN AND AROUND VADODARA !!!!!!!!!!

The Society of Power Engineers (India) Vadodara Chapter jointly with **Gujarat Energy Development Agency (GEDA) Gandhinagar** have taken up the initiative to spread awareness of Energy Conservation Programme.

This Program was initiated by **Ms. Sheetal Shinkhede** (Prof., Polytechnic, MSU, Vadodara) and supported by all EC & AC Members of the SPE (I), Vadodara Chapter. This programme is now coordinated by **Er. (Ms) Sheetal Shinkhede, Er. PA Shah, Er. (Ms) Hetal Prajapatti, Er. (Ms) Binal Modi, Er. YV Joshi, Er. Umesh Parikh, Er. SM Godkhindi, Er. VB Harani, Er. SM Takalkar, Er. SM Baxi** and others

Accordingly, it is planned to organize an Elocution Competition for the students of Diploma & Degree from all disciplines of Engineering Colleges and Universities in and around Vadodara.

The main theme of competition is Energy Conservation which includes following:

1. Green Building
2. Renewable Energy
3. Energy Management
4. Net Zero Carbon
5. Climate Impacts

The response from the various colleges is very good. More than 150 (one hundred fifty) students have registered their name for the Competition. Accordingly first round of competition for some colleges are conducted successfully as under:

FIRST ROUND:

On **22nd March 2023** – Diploma Students of Diploma Studies of Parul Institute of Engineering and Technology, Parul University.

On **22nd March 2023** – Degree Students of Parul Institute of Engineering and Technology, Parul University.

On **27th March 2023** – Diploma Students SB Polytechnic, Savli

On **27th March 2023** – Degree Students of KJ Institute of Engineering and Technology, Savli.

On **4th April 2023** – A round of competition for group colleges was conducted in which SVIT, Vasad; B & B Polytechnic, Vallabh Vidyanagar; Govt. Polytechnic, Bharuch; Polytechnic, MS University Vadodara; Faculty of Technology and Engineering, MS University Vadodara and LD Engineering College, Ahmedabad have participated. This round was taken ON LINE as the participants are from various distinct places.

Few photos of the First Round are exhibited below:

INAUGRAL FUNCTION AT PARUL UNIVERSITY

Dr. Satish Chetwani, Director ERDA; Er. GV Akre, Chairman; Er. PA Shah, Er. Umesh Parikh, Er. SM Baxi, Er. Puntambeker from Society of Power Engineers (I) Vadodar Chapter and Dr. Ruchi Shri Vastava, Prof. Hetal Prajapati, Prof. Dr. JJ Patel; Prof. Binal Modi, Prof. Risil Bhagar, from Parul University at PU, Waghodia – Vadodara.

PARTICIPANTS AT PARUL UNIVERSITY

INAUGRAL FUNCTION AT KJIT, SAVLI

Er. PA Shah, Er. NG Yadav, Er. SM Baxi, Prof. Hetal Prajapati, Prof. Binal Modi, from Society of Power Engineers (I), Vadodara Chapter and Prof. PB Shukla, Prof. Makwana, Prof. Sweta, etc. from KJ Institute of Technology at KJIT.

Participants of KJIT, Savli

It is proposed to conduct Second Round at ERDA, Vadodara on 7th April 2023 and FINAL ROUND of the competition is due to be held at Vasvik Auditorium, the IE(I) some time in middle of May-2023.

The success of these events will lead to a better interaction between SPE(I) Vadodara and the Technical Academic Institutions around Vadodara.

NEW LIFE / YEARLY MEMBERS ENROLLED DURING JAN & MAR-2023

G.R. No.	Grade	Name
2413	LM	Hemangkumar N Shah
2414	LM	Apurva P Vors

OBITUARY

Er. BN Solanki, Retd. EE, GEB and **Life Member of Society of Power Engineers (I), Vadodara Chapter** passed away on **19 Feb 2023.**

He worked in GEB in Distribution and Transmission departments and retired as Executive Engineer. He was friendly and jolly by nature.

He was an active Member of the Chapter.

May God give peace to the departed soul and give strength to his family members to bear the impact.

Er. Pankajbhai (Thakorbhai) M Shah, Retd. Chief Engineer (Gen.), GEB, Head Office and **Life Member** of **Society of Power Engineers (I),** Vadodara **Chapter** passed away on **04 Mar 2023.**

A Graduate in Electrical Engineering from Faculty of Technology & Engineering (Kalabhavan), The MS University of Baroda, Vadodara, he joined erstwhile GEB as Deputy Engineer and superannuated as a **Chief Engineer (Gen).**

During his tenure in GEB, he possessed vast experience in the fields of Distribution (then O&M), Transmission and Generation. He was the main **Architect** in commissioning Wanakbori (210MW), Sikka (120MW) and Panandhro-Kutchh Lignite (70MW) units. He also commissioned Mini Hydel Units.

He was an exponent in System Protection, Relay Co-ordination, Retrofitting of Protection etc. He was aware of the special methods of Generating unit synchronization.

Under his able leadership, following schemes were initiated in GEB sub-stations and power stations which saved Gujarat Power Network from cascade tripping on many occasions.

1. Under Frequency Relay and Grid Isolation by df/dt Relay on sub-transmission system.
2. Distance Relay Protection
3. Busbar Protection

After retirement from GEB services, he continued to share his knowledge & experience for (i) commissioning GMDC, Akri Mota, Power Plant (ii) Mini Hydel Units of Madhuban Dam and Canal Head (on Damnaganga River) (iii) Mini Thermal Power Plant using forest wood as Fuel at Sirohi (Rajasthan). He was associated with Takalkar Power Engineers & Consultants for training Engineers and preparing various protection schemes for clients in up countries as well.

Last but not the least, he was the best coordinator between the then GEB and Power Ministry of Gujarat.

He was an active Member of the Chapter

In his death, SPE (I) Vadodara lost an Expert and Experienced Engineer.

May God give peace to the departed soul and give strength to his family members to bear the impact.

Er. SK Mahendru, Retd. Chief Engineer, GEB passed away on **09 Mar 2023**. He was a Founder of **DETA** (Deputy Engineer & Technical Assistant) **Association** in the erstwhile GEB.

As GEB was progressing after bifurcating from Bombay State Electricity Board, the grass root level engineers i.e. DE & TA were working in an unorganised manner leaving their future at the helm of bureaucrats. Er. Mahendru brought them under one umbrella known as **DETA Association**. He was a fierce fighter for Engineers' Pride, Dignity and Rights.

He obtained the First negotiated Wage Settlement for engineers by way of Dr. Kurien Award. He was a straight forward, smiling and powerful leader of the engineers. He also managed and successfully supported engineers in a very crucial time of **Emergency** by tackling critical issues with the then management. Indeed his contribution to the engineer fraternity of GEB is unforgettable.

May God give peace to the departed soul and give strength to his family members to bear the impact.