Certification Level 3 – Expert in Grounding, Lightning, Transients & EMI

Candidates must acquire the following skills in order to be certified.

Level 3 Certification: Expert in Grounding, Lightning, Transients & EMI

The Expert Certification training provides Level II graduates that have not completed both Level 2 specialization focuses (i.e., substation grounding or power line EMI), the ability to refocus on the missing specialization and carry out transient studies involving power system effects on low voltage circuits and design corrective measures. This Level 3 Certification is intended to ensure mastery of use of the CDEGS software package to solve complex engineering problems. Level 3 graduates are recognized by SES as expert consultants in the areas of power system grounding, EMI, lightning and other transients. They are expert users of the CDEGS software package.

Prerequisites:

- Practical Experience: At least three years of work experience in electrical engineering; alternatively, a degree in electrical engineering or physics and two years or more of work experience in electrical engineering. The candidate must also demonstrate proficiency in the Level 2 specialization previously chosen.
- Level 2 Certification

Period of Validity:

Four years. After this period, the candidate must attend an updated course and pass the associated exam.

Course Description:

This course consists of the complement (if applicable) to the Level 2 specialization previously chosen by the candidate, as described in the Level 2 curriculum, as well as the following subjects:

- Calculation of the self and mutual impedances of arbitrary 3D circuits made of conductor and complex cable systems.
- Determination of interference (EMI) caused by complex energized systems on exposed low voltage circuits during normal, fault and transient conditions such as magnetic fields from reactors and back-to-back switching of capacitor banks.
- Design of efficient shielding systems.
- Study of transient performance of electric installations subjected to lightning or surge currents.
- Design of mitigation measures aimed at suppressing or reducing EMI levels.

Upon successful completion of the Expert Certification course, candidates will therefore have a well-rounded education and expertise in the areas of high voltage substation grounding, AC interference from high voltage lines and large magnitude transient interference with low voltage circuits. The participant will be able to perform complex technical tasks independently and advise others on the performance of these tasks, as well as be able to evaluate, synthesize and communicate abstract concepts and make judgments about information and validity of ideas.

Candidates for the Expert certification level must complete and pass an exam at the training session to verify their mastery of the material taught at the course. They must also be able to demonstrate their experience and proficiency in their Level 2 area of specialization (e.g., attendance at SES Users Group Conferences, technical reports, publications, etc.).

1. Calculation of the self and mutual impedances of arbitrary 3D circuits

- Model Capacitor Bank busbars A, B, and C, at $f = 1{,}590\ \mathrm{Hz}$.
- Compute Self and Mutual Impedances between all pairs of lines.
- Compute the inductance and capacitance matrices.
- Determine influence of the underlying grounding grid on the circuit composed of lines A, B, and C.

2. Interference Issues During Normal Conditions

- Build a set of three-phase 345 kV reactors.
- Determine the best way to connect the reactors to the power sources in order to reflect accurately the magnetic effects of the reactors.
- Determine the appropriate mitigation methods required to avoid excessive induced currents in conductors and structures.

3. Examine Back-Back Switching of Capacitors Banks

- Specify all required information and data that must be collected from all stake holders in order to be able to build realistic and accurate computer models of a back-to-back switching event.
- Build accurate models of the substation including the capacitance banks.
- Build appropriate substation structure configurations.
- Model control cables from the capacitor bank area to the control room.
- Select appropriate cable sheath grounding models of the control cable and examine various grounding schemes including shielding and parallel neutral wires in the cable trench.

4. Design an Efficient Shielding System

- Export the substation to SESShield-3D. Enhance the model.
- Add lightning masts as necessary to insure that lightning is intercepted at all exposed locations using the standard Rolling Sphere method.
- Carry out similar analysis using all other applicable methods. If the designed shielding system fails for any of the other methods, determine what is needed in order to make sure that lightning is intercepted for all other methods.
- Export the designed shielding system back to MultiFields.
- If necessary, verify that the induced currents in the substation with the addition of the shielding system are still appropriate.

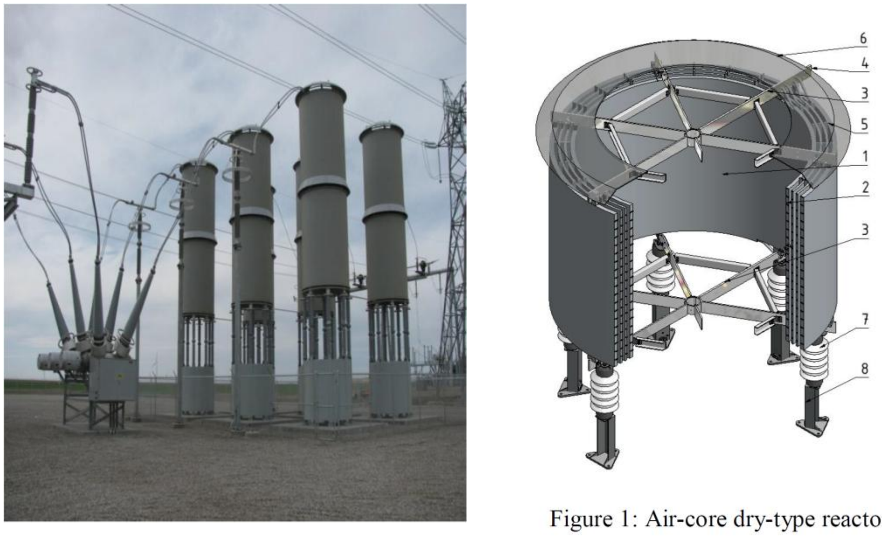
5. Analyze The Shielding System Lightning Performance

- Using the alternate software package (i.e., the one selected above for validation purposes), carry out a comprehensive analysis of the performance of the entire joint-use corridor during steady-state and fault conditions based on the single type of soil structure model selected above and for the most stringent steady-state and fault conditions encountered during the preceding analysis as done above.
- Confirm that, in all likelihood, the computer model as built does indeed represent a realistic rendering of the real situation.
- Carry out a quick safety analysis of the substation and discuss mitigation measures without implementing them in the computer model.
- Understand Stake Holders Issues
- Understand reasonably well the concerns of gas and oil pipeline companies, railway companies and communication line companies in order to address all important issues adequately.
- Evaluate equipment and material integrity issues and electrical safety concerns along the pipeline route and be able to identify unsafe conditions specific to each utility or industry.

6. Conclusions

- Describe briefly the most salient findings and knowledge that you have acquired during this training that you were not aware of before.

For such applications important aspects must be analyzed as the transmission system performance under steady-state and transient conditions, the definition of the physical dimensions for the equipment, the specifications of the electrical characteristics and the special cares with respect to the possible damages caused by the magnetic flux generated by the CLR to human life, directly or through contact with metallic structures in the vicinities. Equal importance should also be given to the economic profits of this limitation in short-circuit level compared to the costs of the substitution of overstressed equipment and facilities. Table II shows basic characteristics of FURNAS 362kV CLR.

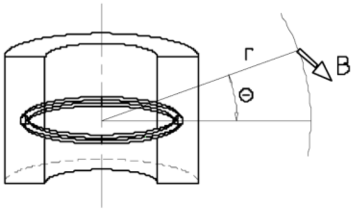


1 - Winding
2 - Winding conductor
3 - Spider
4 - Terminal
5 - Duct stick
6 - Protective roof/shed
7 - Base insulator
8 - Mounting bracket

Figure 1: Air-core dry-type reactor

$$|B| = \frac{\mu_0 . n . I . D^2}{8 . r^3} f(\Theta) \qquad (1)$$

$$f(\Theta) = \sqrt{\sin^2(\Theta) + \frac{\cos^2(\Theta)}{4}} \qquad (2)$$



|B| .... magnitude of the magnetic field
μ_0 ...... permeability in air ($\mu_0 = 4\pi.E\text{-}7$ H/m)
n .... turns number
I .... current
D .... loop diameter (= mean winding diameter)
r, Θ ..... coordinates as per Figure 3
f(Θ) ..... directivity function as per equation (2)

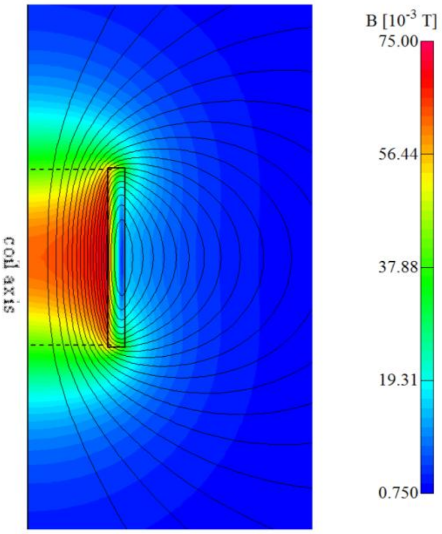
Rated voltage (kV): 345 - rated frequency (Hz): 60 - per phase inductance (μH): 24000 - rated current (A): 2100 - maximum voltage drop (kV, RMS): 18,9 - rated power (MVAr): 40 - rated short-circuit current (kA, RMS): 25 - impulse insulation level (kV, peak) 1300 - switching insulation level (kV, peak) 850 quality factor: 300 - type of installation: external

MAGNETIC FIELD CONSIDERATIONS

As the name implies, air-core reactors do not have an iron core and therefore the magnetic field is not constrained and will fringe out from the winding ends and will occupy the space around the reactor winding. The strength of this stray field depends on the unit power rating of the reactor, the higher the rating, the higher the magnetic field level. Figure 2 shows the magnetic field plot of an air-core reactor. The selected example is one phase of a 69 kV, 50 Mvar (50 Hz) wye connected 3-phase

Reactor Bank.

Reactor data:
reactance (50 Hz) .... 95.2 Ohm
inductance .... 303 mH
winding length .... 2.7 m
mean winding diameter ...... 2.56 m
turns number 450
current .... 418 A(rms)



For system voltages of around 230 kV two single units, stacked one above the other and connected in series are required to keep the winding voltage stresses within acceptable limits. For even higher voltages more than two series connected winding modules are required which is achieved by a separately side-by-side mounted reactor stack connected electrically via cables or buswork. Standard phase to phase and phase to ground electrical clearances used by the utility are applicable for theses reactors. Figure 4 shows a 345 kV, 20 Mvar, 60 Hz, shunt reactor bank. Each phase consists of totally 4 series connected winding modules each having a winding height of 3.55 m. The space requirement for this 345 kV dry-type air core shunt reactor bank is around 17 m x 12 m. However, because the reactors are typically custom designed, the coil dimensions and coil orientation can be adjusted to suit site conditions.