Roadmap for human resources for expanded Indian nuclear industry

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Abstract

This paper deals with detailed requirement of human resources for all phases of nuclear power plant, for the manufacturing sector and the probable roadmap for achieving India's target. The accident in Fukushima has brought out that only nuclear power that avoids being a threat to the health & safety of the population and the environmental will be acceptable to the society and for this to be achieved human resources could be a single major contributor. India has ambitious plan of achieving 20,000MW by 2020 & 63,000MW by 2050. It is felt out of the three resources men, material & money; the critical shortage would be human resources both in quality & quantity. As per IAEA report (Publication of 2008 edition of energy, electricity & nuclear power estimates for the period of 2030), nuclear capacity must grow to at least 1.8 times current capacity by 2030 if global temperature rises are to be kept at 2°C. Objective of recruiting & training human resources for Indian Industry can be as follows:

a) For catering domestic market.

b) For catering international market later on for nuclear industries outside India. As India will be an important future international player.

The above would require a multiplication of human resources by nearly seven times. In addition it has to be wholesome covering all levels & all skills and all disciplines & stages covering the whole nuclear cycle including regulators. Human resources are required for design & engineering, construction, commissioning, operation, manufacturing & for support services. The manpower for these has to be trained to achieve high quality of nuclear standards. Presently Indian Department of Atomic Energy(DAE) runs several training schools giving one year Post Graduate, tailor made courses. This needs to be multiplied by Joint efforts. Training should be on "SAT (Systematic Approach to Training)" methodology to ensure focussed, specific, needed to culminate in safe, reliable and viable operation of NPPs & other nuclear facilities. On the job training should be given due emphasis. Training is management responsibility. Private companies should consider resources spent on human resources development as a good long term investment and should set up organisation, system, procedures etc. for training. Nuclear power plants require lifetime technical and design support and for this corporate memory/knowledge management assume vital importance.

The trait of the nuclear industry to learn from good practices, operational experience, feedbacks etc. needs to be further strengthened. Nuclear is knowledge driven industry and organisations should ensure the attainment of the same.

1. Introduction

As of now Nuclear Energy is the only alternate BULK energy source to carbon based fuel which will exhaust perhaps sooner than later. Nuclear energy offers security, independence, greenhouse gas free, sustainable development, balance in the energy mix and abundant (adequate for 300 years of global requirement) and bulk source (which renewable is not even though this source also needs to be developed aggressively).

Emerging economies needing power and who have announced plans for going/ augmenting nuclear are not stopping the program after Fukushima but would upgrade safety. Developed nations with less than few percent growth & stagnant energy needs may slow down. Even among these, except Germany & Italy replacements would still be from gas & nuclear. It may be noted that generation 3, 3+ NPPs which India would be importing as well as Indian PHWRs will withstand a Fukushima type of multiple natural disasters with almost no or minimal action in public. At Fukushima rehabilitation of evacuees has commenced. Neither occupational workers nor public got any radiation exposure that will cause health effects in short or long term or genetic effect. So global renaissance will, in all probability go on but could be slowed down marginally. In my opinion a revisit on safety & nuclear security (against sabotage & unauthorized removal of its nuclear material) to be done for such multiple natural disasters, emergency preparedness and accident management systems, station blackout & dedicated independent diesel generators, hydrogen management, redundancy in reactor fuel cooling, spent fuel storage & cooling, multi-unit safety and sharing of systems etc. This review will be a parallel effort. Thus fission reactors would be a bridge between carbon based fuel & fast breeder reactors & later fusion reactors.

The debate on whether to have nuclear power for India or not is going on for the last thirty years. With twenty nuclear power plants operating and six under construction, it is too late to ask this question. Constructive criticism and debate should now be on what additional safety and commercial up gradation should be done to make nuclear power safe, secure, reliable, viable and acceptable, what type of nuclear power plants should be built, what are specific needs of our culture and for our country, which technology, in addition to Pressurized Heavy Water Reactors, should India absorb for domestic use and tap huge export potential, what additional steps should be taken to speed up putting thorium usage into commercial domain, road map to make India an important global nuclear player similar to IT now etc. Just because a knife can cut one's fingers, we are not getting rid of knife but continue its use while improving its design & exercising greater safety in using it. For balanced energy mix, energy independence and security, climate change and avoiding green house gases, sustainable development, tapping 25% of world thorium being in India capable of producing three lakh Mega Watts for three hundred years and the huge potential of India being a major global nuclear player in a decade (like IT, auto industries etc now) and many other reasons, nuclear is inevitable for India. Nuclear industry will go through some changes but the need for nuclear will not change. However constructive criticism and debate is required to fine tune the policy. Political consensus is a must. Media would continue to play a major role. The way all these are playing vital roles in the last few years on many issues augurs well and gives confidence that the country would chalk out a mature, effective and best suitable nuclear road map for India.

India has ambitious plan of achieving 20,000MW by 2020 & 63,000MW by 2050. It is felt out of the three resources men, material & money, the critical shortage would be human resources both in quality & quantity. As per IAEA report (Publication of 2008 edition of

energy, electricity & nuclear power estimates for the period of 2030), nuclear capacity must grow to at least 1.8 times current capacity by 2030 if global temperature rises are to be kept at 2°C. It will require significant emission reductions in all regions & technological breakthrough, It is further mentioned that two third of the reduction must come from power generation sector. Hence more emphasis will be on nuclear power. This global nuclear renaissance is widespread, irreversible & will be sustained.

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It can be divided in following categories:

i. Human resources required to design & engineering.
ii. Human resources required to construct the power plant.
iii. Human resources required to commission the power plant.
iv. Human resources required to operate the power plant.
v. Human resources required by manufacturing industries to manufacture nuclear components.
vi. Human resources required for support services.

All the manpower has to be trained to achieve high quality of nuclear standards.

At present all the above are done under one umbrella by Nuclear Power Corporation of India Limited of Department of Atomic Energy. Now such an ambitious target is proposed to be met with participation of foreign technological providers, government owned companies & Private companies. As per the present atomic energy act, private companies can have minority stake with govt. owned co. like NPCIL to gradually develop core competence and human resources to play a gradually increasing role.

For the nuclear industry to realise its ambitions following requirements to be met in chronological order (which is already possessed by NPCIL).

1. Capability to be technology provider.
2. Site selection & Site development.
3. Project management till commercial operation.
   - 3.1 Pre-project activities.
   - 3.2 Experience in procurement of nuclear components (EPC packages).
   - 3.3 Experience in construction of nuclear plant.
   - 3.4 Experience in commissioning of nuclear plant.
   - 3.5 Experience in operation of nuclear plant (should be able to operate safely, reliably & viable).
   - 3.6 To meet AERB requirements & other statutory stipulations (including setting up of good safety management system, organisation, procedures etc).
   - 3.7 Experience in radiological safety system & radio-active waste disposal system.
   - 3.8 Decommissioning of nuclear plant (to be met later on).
   - 3.9 Training and Licensing of operating persons of private company. This can be part of National policy.

3.10 Adherence to Bilateral agreements, NSG Waiver, IAEA safeguard protocol and international conventions & requirements (Similar requirements will be there for back & front end of Nuclear Fuel Cycle) Interfacing/Interaction.

Government policy should address & issues related with closed cycle, reprocessing rights of Imported spent fuel, life time fuel supply, gradual indigenisation and absorption of technology. Privatisation as per amended act & road map with time line. Item number 1 & 2 should be with Government owned organisations. Human resource development needs to be integrated with all these.

In the first phase, since design is imported, private companies should acquire experience in procurement (EPC packages), Project management, Operation of plant & Develop good safety culture and develop core- competence (Training & Licensing of operating personals) & then only take up 100% privatization. Period for this is approximately 8 years. NPCIL may also have to double or even triple the HRD requirements.

Public – private partnership is the way forward for nuclear power sector & the expertise, know how culture, good practice etc will be transferred from NPCIL to the private players. This will imbibe confidence in the regulatory body, Policy makers, Govt., Public at large (Public acceptance), other stake holders & enable gradual, step wise, sustained & irreversible movement towards the ultimate goal of full privatisation in parallel with amendment of act. This can be an ideal initial step. It is also felt that Govt. is required to play an important role in the management of NPP projects in view of Govt. commitment to IAEA, which may not be known to private players.DAE units including NPCIL need to give a parental education & upbringing to private players who are their children in the larger objective of achieving the nation targets.

While initially training can be a Joint effort between DAE units and private companies, it is important for private players to gradually develop their own organisation, system, procedures, trainers etc. for training. Training is Management responsibility and they should set up the above framework. However to get trained is the responsibility of each individual. Also one must realise that a small training section cannot cater for the stupendous job of training specially for Nuclear Industry, as training has been its asset. It should be the responsibility of all the staff to impart training and knowledge transfer in a continuous manner. Also training is an eternal process specially if one wants to achieve excellence which is a continuous journey and not a destination.

Training should be by "SAT"(Systematic Approach to Training) methodology. First the major Objectives/Tasks of the company need to be drawn up. Then the competency required in the staff to achieve these Objectives/Tasks need to be worked out. After courses need to be detailed to acquire above competences. On the Job Training should be an important component. Also review needs to be dynamic and every failures/performance shortages to be analysed to determine for any Correction/Addition in Training.

2.0 Human resources required for construction of Power Plant:

It is assumed that construction will be in parallel at multi site in India for achieving the goal. Man power can be divided into the following two categories:

a. Company's own man power- this includes Engineers & Supervisors.
b. Contractors man power for executing EPC contracts and outsourcing of supporting services.

a. Company's owned Man Power:

Around 350 persons will required = 250 - Engineers
50 - Supervisors

In addition 50 persons will be to cater for support function in non core areas.

b. Contractor's Man Power:

During construction period of 5 years for one site. It will be as below

1st year = 500 persons
2nd year = 1500 persons
3rd year = 3000 persons
4th year = 10,000 persons
5th year = 1000 persons

It will include around 100 Engineers, 50 Supervisors & rest Fitters, Welders & other work forces etc. Safety persons will be required to train the persons before they are deputed on job. So that no accidents takes place. The work has to be done at 4 sites simultaneously – Requirement will be around 40,000 persons.

3.0 Human resources required to commission the Power Plant:

In order to reduce gestation period of plant, it is required that construction & commissioning are done in parallel hence for 1st unit , O & M team along will be construction team can be utilised for commissioning of plant. For 2nd unit , extra person (who are trained & experienced earlier)) have to be utilised.

Commissioning team will be mix of experienced person & fresh persons. These extra persons can be deputed to other site subsequently.

4.0 Human resources required to operate the Plant:

These personals will be responsible for safe operation of plant. Following requirement has to be met.

4.1. General

4.1.1 The site organisation i.e. the plant management (see Annexure-II) has the immediate responsibility to meet the requirements for commissioning of the plant & for the safe and reliable operation of the plant.
4.1.2 The plant management shall identify the functions to be carried out at the site to meet the above stated objectives. The operating organisation should decide functions to be performed at site, within operating organisation and off-site by agencies outside the operating organisation.
4.1.3 On the basis of these decisions and of all applicable regulatory requirements, the operating organisation shall establish an organisational plan for plant management indicating

general policies, lines of responsibilities and authority, lines of communication and number of persons needed along with their qualifications. These should be documented in approved formats and maintained according to approved procedures.
4.1.4 The organisation structure shall be established well in advance (about 3 to 4 years) of the nuclear power plant commissioning and operation, since it is the basis for subsequent requirement and training.

4.2 Bases of Organisation

4.2.1 Functions important for safe operation of NPP are performed both on-site and off-site. Typical on-site functions include personnel administration procurement of materials or services, design of plant modifications and special technical support.
4.2.2 Functions performed off-site may have a bearing on safety and therefore programmes of specific training for such personnel involved shall be established along with quality assurance requirements.
4.2.3 The different approaches to problem solving adopted by operating organisations have a significant bearing on the size of the site organisation. The selected organisation structure should be described in detail in a document with clear emphasis on responsibilities, authority, interface and lines of communication.
4.2.4 The following considerations may influence the determination of the positions and the number of persons in the organisational structure:
a. The number of persons in each shift shall be sufficient to deal safely at any time with all operational states and accident conditions, with consideration given to the possibility of keeping some persons on call and adequate relief duty and to the time needed for such persons to reach the site. The possibility of abnormal events occurring at odd hours shall be considered.
b. The shift crew personnel should be provided with facilities for training and re-training. The number of shift teams is generally subject to national and local regulations and agreements; however, off-shift time for continuing training purposes should also be provided.
c. The organisational structure shall be such as to permit the performance of the duties assigned to the site personnel in the emergency plan, with consideration given to the possibility of keeping some persons on-call and to the time needed for such persons to reach the site.
d. The location of the plant relative to the off-site support organisation shall be taken into account.
e. The number of persons assigned for any given activity important to safety (e.g. instrument technician etc.) shall be determined allowing for absence due to continuing training, sickness, vacations etc., and the minimum requirements to meet the plant needs.
f. The expected turnover rate and time to recruit train and qualify replacement personnel as well as staff requirements for expansion programs.
g. The availability of obtaining off-site personnel for planned or unplanned replacement or reinforcement shall be considered (e.g. increased maintenance staff during annual or capital shutdown).

4.3 Functions of Plant Management

4.3.1 The following are the main functions of plant management:

1. Operation

2. Maintenance

3. Technical support

4. Quality assurance

5. Training

6. Industrial safety including fire safety

7. Health physics

8. Radioactive and other effluent management

9. Physical protection

10. Emergency response preparedness

11. Personnel management

12. Materials management

13. Financial management (accounts)

4.3.2 The functions are categorised as:
1. Direct operating functions
2. Support functions
3. Service functions

4.3.3 Direct Operating Functions

Those functions which affect the operational states of the plant (such as control room and field operations).

4.3.4 Support Functions

4.3.4.1 The supporting category includes the following function:

i. Systems review, performance checks, analysis and modifications
ii. Health physics and radiological protection
iii. Fuel handling
iv. Mechanical maintenance
v. Electrical and instrument maintenance
vi. Quality assurance
vii. Reactor physics and fuel management
viii. Chemistry
ix. Planning and scheduling
x. Spent fuel storage
xi. Training
xii. Security
xiii. Industrial and fire safety
xiv. In-service inspection
xv. Waste and effluent management
xvi. Environmental radiological laboratory(ERL) (support function and independent of plant management)
xvii. Civil/services maintenance
xviii. Heavy water management and handling (only for PHWR Plants)
xix. Interface with Regulatory Body, grid and state authorities

In addition to above, the persons are also required to cater for Administration, Accounts, Transport, Security, Medical etc.

Requirement of persons for twin units will be as follows: (Company's Manpower)

Engineers: 300 Nos.

Supervisors: 100 Nos.

Technicians: 200 Nos.

Non core group:

Engineers : 30 Nos.

Supporting Staff : 20 Nos.

It is assumed that large number of jobs will be outsourced. Hence approximately 600 number of work force will be required from Contractor side. Engineers: 30, Supervisors: 50, Work Force: 520(approx.)

In order to have safe & trouble free operation and to met requirements of regulatory body, following should be met & persons responsible for operation of plant are certified by regulatory body or by anybody approved by regulatory body.

General: Hence it can be summarised as below:

1. The operating organisation of a nuclear power plant has to perform its functions for safe and reliable operation at a minimal risk to plant, plant personnel and the general public. The operating organisation would a be multi-discipline and a multi-tier unit of well-trained personnel which includes the management. It shall establish procedures, norms and practices to ensure high quality of work execution in an orderly manner. All plant personnel should be trained, qualified and certified to achieve the quality of operational activities.

2. Certain functions require rapid response. An erroneous response may lead to a major problem with its attendant consequences. Perhaps, there would also be no time to verify a response plan. The correctness of response would thus depend on the individual's perception, attentiveness and activeness.

To ensure a correct response:

a. Key positions involving such functions shall be designated as certified positions and persons meeting such requirements only should be allowed to perform such functions; and

b. Each of them shall be covered by a retaining programme, minimum once in three years, to maintain proficiency in coping with anticipated operational occurrences and accident conditions and to minimize human errors and should then be recertified for the positions.

3. The operating organisation shall have well established procedures for qualification and certification of all station personnel. The certification procedures for persons holding such positions shall be to the satisfaction of the Regulatory Body.

4. The certification of persons for the key certified positions will be done by the Regulatory Body or by a body approved by the Regulatory Body.

5. Adequate number of personnel required for normal operation should be certified for these certified positions before commencement of operation. These positions must be manned by certified personnel only.

Work on safety systems or safety related systems in the plant which commenced operation should be carried out only after a written authorisation by

5.0 Human resources required for manufacturing Nuclear Industry to manufacture Nuclear components:

It will be a big challenge for manufacturing industries to supply nuclear components to projects under construction. Large No. of trained engineers, supervisors, welders, quality assurance inspectors, & other work force will be required it will be around 40,000 to 50,000 persons in order to achieve cost of power produced from foreign plants comparable to nearest thermal plant in India, most of the components required to be manufactured in India.

6.0 Conclusion:

Following are the recommendations to cater for human resources:

1. More No. of ITI's to be opened across countries to produce trained welders, fitters etc. Nuclear work force require special training for example in nuclear welding, welder, welding procedure and both together needs to be qualified.

2. Engineering college should start B.E in Nuclear Engineering and then Centralized Training Institutes should give one year PG course in Nuclear Engineering.

3. Recruitment and Training has to be done on war footing to achieve National goal.

4. Presently DAE runs several training schools giving one year Post Graduate, Taylor made course. This needs to be multiplied by joint efforts.

5. Training should be on "SAT" methodology.

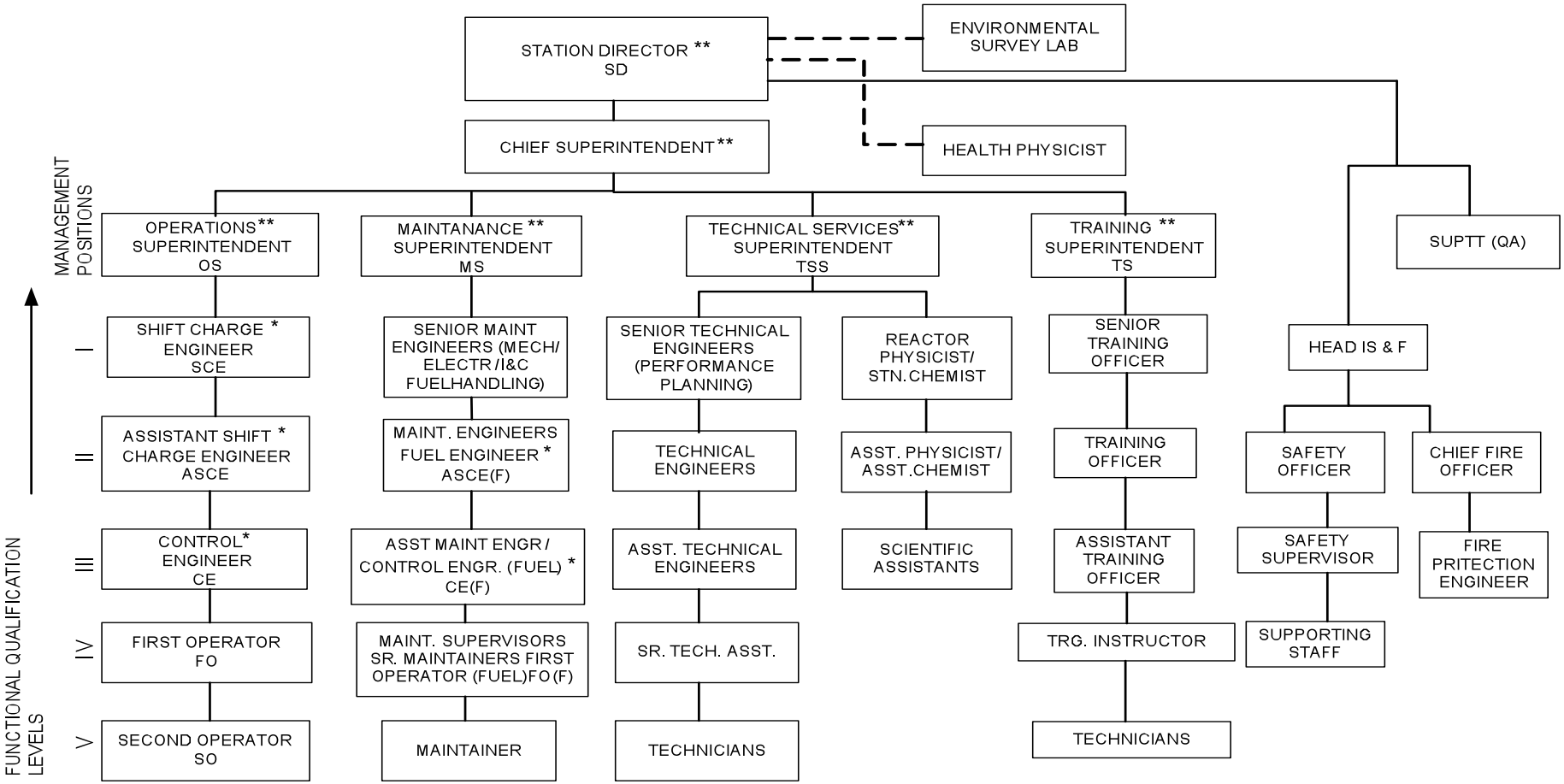
6. On the job training should be given due emphasis.

7. Training is management responsibility. Private companies should set up organisation, system, procedures etc. for training.

8. While serving the huge domestic market can be of immediate interest, India should also plan for catering supply of human resources for global nuclear renaissance. India has all pre-requisites required to take such an important future position of a prime HRD supplier.

9. In the end we want to request INS to take up training activities of persons at engineer, supervisor & workers level. Indian Nuclear Society has large bank of trained human resources in nuclear field. This will help in training large number of persons required for nuclear industries in India.

TYPICAL ORGANISATION CHART OF PLANT MANAGEMENT ANNEXURE-I



NATES
1. HP PERSONNEL ARE ALSO QUALIFIED AS ABOVE.
2. ** CERTIFIED POSITIONS MANNED BY PERSONS HAVING MANAGEMENT QUALIFICATION
3. * CERTIFIED POSITIONS MANNED BY PERSONS HAVING LICENCE

LEGENG
LINE OF COMMAND
LINE OF COMMUNICATION

Annexure-I

Academic Qualifications and Experience:

Sr. No.	Positions (Level)	Minimum Academic Qualification	Training/Station Qualification/Field Experience/Training
1.	SCE (Level-I)	B.E	8 years minimum or equivalent including 2 years as a qualified ASCE in the same or the similar PHWR/LWR in India.
2.	ASCE/ASCE(F) (Level-II) (to be merged in course of time)	B.E	6 years minimum or equivalent including 2 years as a qualified CE or CE(F) in the same or similar plants and with the supplementary FHS or the Main Plant Qualification as stipulated.
3.	CE/CE(F) (Level-III)	i. B.E ii. Diploma Holders in Engg.	4 years minimum or equivalent experience including training on Nuclear Systems, TG Systems, Electrical and Process Auxiliary System Operations and or Commissioning. OR 10 years minimum experience as above including 3 years as a FO/FO(F)
4.	FO/FO(F) (Level-IV)	Diploma Holders/ B.Sc.	4 years minimum including training in field operations in reactor, FHS Turbine and Services systems commissioning and Control Room operations under CE's/CE(F)'s guidance as applicable.
5.	SO (Level-V) (Common for Main Plant and FHU)	H.S.C/S.S.C. (refer 4.5 for exceptional cases)	8 years minimum including training in identified areas of Main Plant, FH and Auxiliary Services.

It may please be noted that for graduate level Engineers to reach SCE level will be 8 years minimum.