Sellafield Ltd 'Nuclear Scientist and Nuclear Engineer' Degree Apprenticeship: Control Systems Pathway Handbook

Introduction

Sellafield Ltd offers a 'Nuclear Scientist and Nuclear Engineer' Apprenticeship. This is a level 6[1] degree apprenticeship. The degree apprenticeship consists of seven pathways, each focusing on a specialism within the overall apprenticeship.

Figure 1: Pathways of the Nuclear Scientist and Nuclear Engineer Apprenticeship

One of these pathways is the Control Systems Pathway. Control systems are used for the monitoring and control of industrial processes, sometimes referred to as industrial control systems (ICS). It involves working with "computer technology associated with detection or control of physical devices, processes and events".

[1] See National Qualification Framework for definition of levels. https://www.gov.uk/what-different-qualification-levels-mean/list-of-qualification-levels

The Apprenticeship Standards

Since April 2017, when the recommendations contained within the Richard Report[1] were implemented, the government imposed a levy on all organisations within the UK with a wage bill over £3m/year. Employers taking on apprentices can draw back money from the levy to pay for them, thus encouraging employers to recruit apprentices. To ensure employers really employ apprentices, each apprenticeship must follow an apprenticeship standard approved by the government. All apprentices on the Sellafield Nuclear Scientist and Nuclear Engineer Apprenticeship will actually complete two apprenticeships defined in the following standards.

In the first three years you will complete a level 5 **Nuclear Technician Apprenticeship** (Standard Number ST0380). A full description of the standard is given here:
https://www.instituteforapprenticeships.org/apprenticeship-standards/nuclear-technician/

In the second two years you will complete a level 6 **Nuclear Scientist and Nuclear Engineer Apprenticeship** (Standard Number ST0289). A full description of the standard is given here:
https://www.instituteforapprenticeships.org/apprenticeship-standards/nuclear-scientist-and-nuclear-engineer-degree/

Each standard has a number of knowledge areas, skills and behaviours that you must demonstrate to the required level to successfully meet the standard and complete the apprenticeship. To confirm you have met the standard there will be an end-point assessment (EPA) towards the end of each apprenticeship. The level 5 Nuclear Technician standard EPA requires you to submit a written **technical report** of between 3500 and 5000 words covering the "broad breadth of the standard". There will also be an interview consisting of a **presentation** and a **structured discussion** on the work you have been doing. The level 6 Nuclear Scientist/Engineer standard EPA requires you to submit a written **portfolio of evidence** built up over the course of your apprenticeship along with a **project report** on a substantial work-related nuclear project. As before there is a **competence interview** to ask questions about the portfolio and project to confirm you have met the required standard. Full details of the end point assessment, for each standard, are given on the previous web pages.

Academic Component

A requirement of the level 6 standard is that upon completion of the apprenticeship you will hold a level 6 honours degree. Hence, in the first three year period of the apprenticeship, you will study for a **Foundation Degree in Plant Engineering**, and in the final two years you will study for an **Honours Degree in Plant Engineering**[2].

These are delivered by Gen2 on behalf of the University of Cumbria on day release. As with all degrees, there is a minimum entry requirement, and the degree standards also specify entry requirements. For the Sellafield Nuclear Scientist and Nuclear Engineer Apprenticeship the current entry requirements are:

- Minimum of 5 GCSEs, of which one must be at least grade B in mathematics and the remainder must be at least grade C, and include English language and one science subject (physics, chemistry, biology or similar).
- Minimum of 96 UCAS points[3], including mathematics and science at A-level grade C or above. Other level 3 STEM qualifications may be considered.

[1] The Richard Review of Apprenticeships (published 2012). https://www.gov.uk/government/news/the-richard-review-of-apprenticeships.

[2] The academic subjects are the same for all pathways with the exception of the scientific pathway.

[3] See the UCAS tariff points calculator https://www.ucas.com/ucas/tariff-calculator. The 96 UCAS points, is the required tariff from Sept 2017. Previously, under old tariff system, it was 240 UCAS points. In both cases it is equivalent to 3 grade C, A-levels.

Control Systems Pathway Structure

All the pathways are broadly similar and start with a 3 month fulltime academic 'bridging course' followed by the apprenticeship proper. This is the structure of the Control Systems pathway at a glance – other pathways will be slightly different.

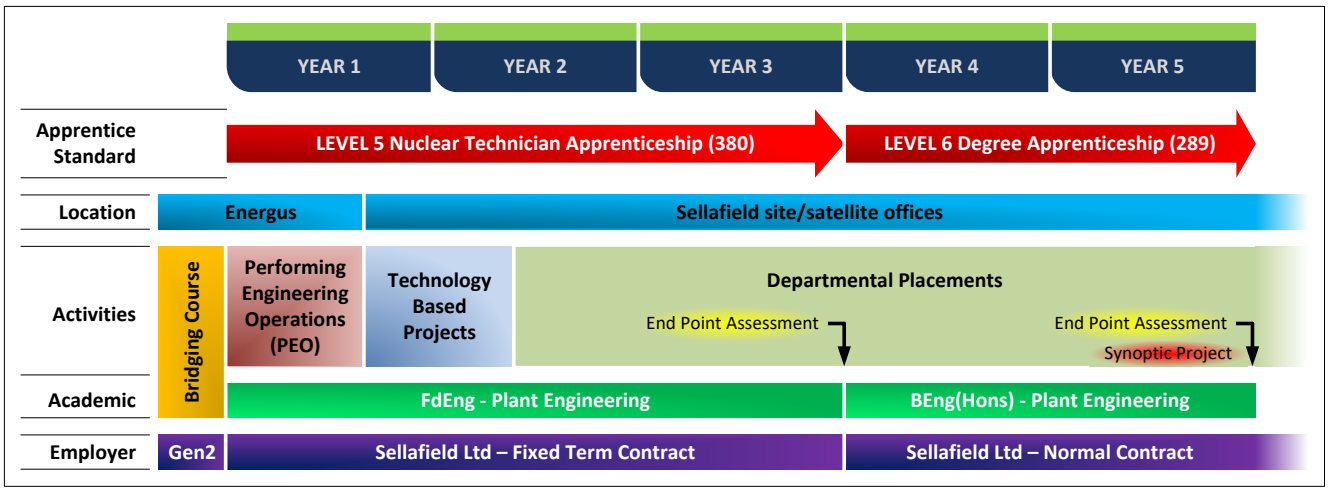

Figure 2: Control Systems Pathway Overview

Bridging Course

The aim of this level 3 higher education bridging course is to prepare you for level 4 studies in engineering and mathematics. This programme provides you with the opportunity to review areas such as physics and mathematics and possibly extend your knowledge in these areas. During this time you will be employed by Gen2 and study within the Energus building. This 16-week block does not form part of the formal five year apprenticeship.

The course has been specifically designed to provide a seamless transfer to the first year of the foundation degree. During this 16-week course you will undertake a series of level 3 modules and projects.

Level 3 modules
BC3001 Mathematics
BC3011 Electrical Science
BC3021 Mechanical Science
BC3041 Fundamentals of Nuclear Science

Projects
Mechanical
Electrical
Control Systems/Nuclear

In the projects, you will be expected to research, understand and apply academic research, report writing, referencing, basic project management techniques, and practical experimentation on the subjects listed above.

Performing Engineering Operations (PEO)

Following on from the bridging course you will become a Sellafield Ltd employee (on a fixed term contract) and the 1st January marks the start of your formal five year apprenticeship. Many of the Nuclear Scientist and Nuclear Engineer Apprentices move to team placements around the site and outlying offices, however, apprentices on the Control Systems pathway will remain at Energus for a further 9 months. In the Control Systems profession, you may be required to work in situations that are potentially hazardous. Therefore:

- You need to be able to use tools and equipment confidently and safely.
- You need to be able to identify conventional and electrical safety hazards.
- You may need to gain a formal appointment to work on electrical equipment.
- You may need an understanding of the basic underlying engineering principles such as a structured approach to fault finding.

The PEO is a formal NVQ level 2 course designed to give you this practical experience.

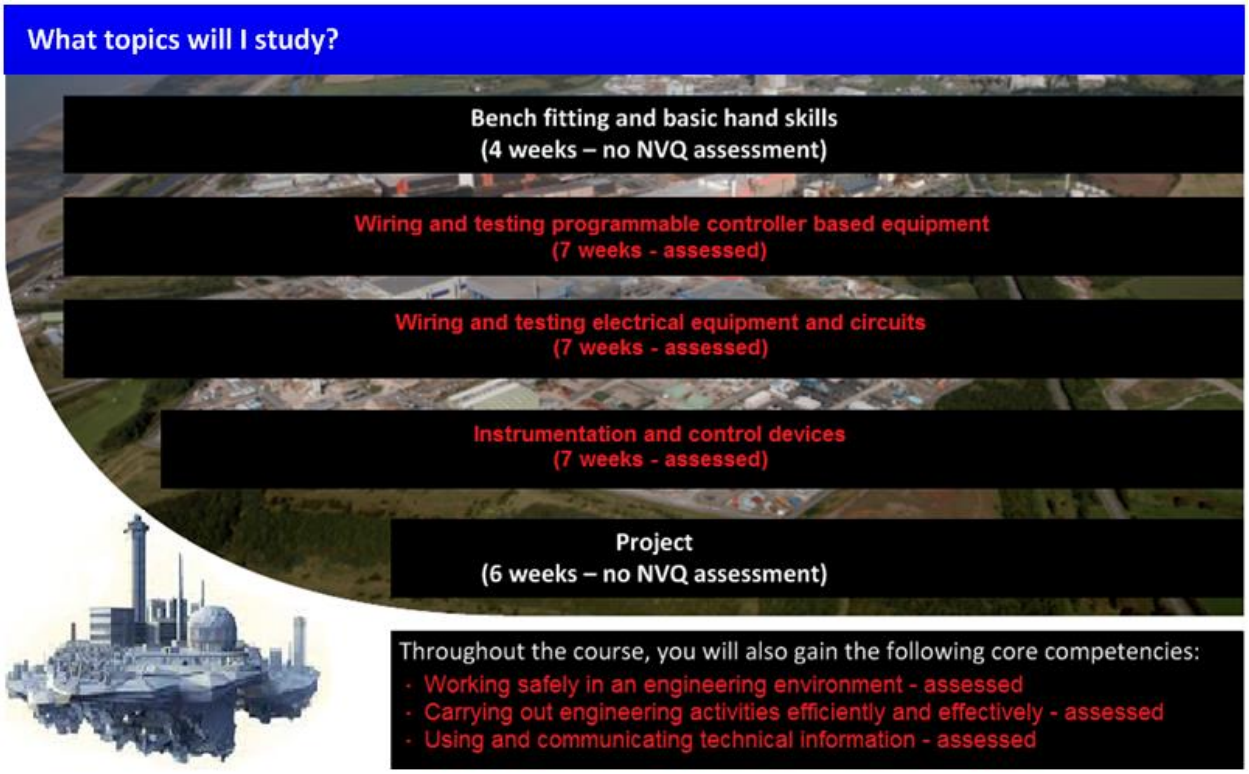

Figure 3: Structure of PEO

You will be assessed during the PEO course. Formal NVQ assessments will be carried out for the six topics highlighted in red above, and an NVQ Level 2 qualification in 'Performing Engineering Operations' will be awarded at the end of the course.

The final project element is intended to consolidate the learning from the other modules.

Technology Based Project Modules

Once the PEO has finished you move to the Sellafield site or outlying offices, e.g., the Albion Centre in Whitehaven, to complete a number of technology based 'project' modules. Each module is usually around 8 weeks and the content is summarised below. These project modules will last for approximately 34 weeks. These are mentor lead, i.e., you will be given instructions, followed by tasks to complete and then mentored as you complete the tasks. You will need to think independently, using your initiative, but work as a team and come up with solutions to the given tasks.

Apprentices complete four mentor guides.

Distributed Control Systems (DCS)

- Illustrate DCS architecture and describe the functionality of hardware node types.
- Demonstrate the features of the MOD300 and navigation around operator displays.
- Build a DCS system using information from vendor manuals.
- Produce design documents for basic control schemes, complex control schemes, and control sequences.
- Reverse engineer design documents from code.
- Design code using Function Class Modules and TCL (Pascal).
- Demonstrate use of the dynamic debugging tool to interrogate the MTOS operating system used on the MOD300 DCS system.
- Design, implement and test a complex modification to the off-line Trainee Simulation software.
- Explain the difference between the legacy MOD300 system and the latest DCS offerings from DCS vendors, and the differences in configuring modern platforms.

Network, OS, MIS & IPES

- Identify clear zones and assign appropriate subnets to separate out the zones and allocate IP Addresses to devices within each zone.
- Configure a switch, firewalls and a Network Monitoring Station.
- Install and configure Client and Server Operating Systems and apply Service Packs and Patches.
- Apply Secure Build Configuration to Client and Server Operating System.
- Apply Malware Protection to Client and Server Operating Systems.
- Assemble and configure an IPES system based on a Raspberry Pi and program it using Python.
- Present the user with information about various measurements taken from a Raspberry Pi using the Sensor HAT.
- Construct code in C# to accept data from a Raspberry Pi and store the information locally and in a MIS.
- Install and configure Oracle Software then create a new database instance using Oracle Database Configuration Assistant (DBCA).
- Construct an Entity Relationship Diagram (ERD) to document entities and attributes for the control system.
- Normalise ERD and translate into Schema Diagram. Use Schema Diagram to construct scripts that will create the database tables and indexes within the data files previously created.
- Construct PL/SQL modules to interact with the database tables, store information from the Raspberry Pi and facilitate other functions identified by the design.

PLC & SCADA

- Demonstrate an understanding of the standard hardware components of an Allen-Bradley PLC (e.g., rack, CPU, PSU, IO modules, remote IO, and special modules.
- Demonstrate an understanding of the common input and output types (e.g., discrete and analogue)
- Demonstrate an understanding of Allen-Bradley PLC software (i.e. logic scan dynamics, error handling, programme architecture, instruction set, and annotation).
- Produce a working PLC programme in ladder logic using the Allen-Bradley PLC development application RSLogix, and carry out modifications to existing PLC ladder logic programmes.
- Carry out fault-finding using the PLC and associated support tool (i.e. laptop).
- Demonstrate an understanding of SCADA (i.e. functionality, best practice, limitations, naming conventions, graphics / ergonomics)
- Demonstrate an understanding of the communications between SCADA and other components in the system (e.g., other SCADA PCs, PLC, network switch, terminal server, laptop/development PC).
- Produce a working SCADA application, and carry out modifications to existing SCADA applications.
- Demonstrate an understanding of the functionality provided by a simple SCADA application by offline interrogation of the application.

Radiometrics

- Demonstrating an understanding of the techniques for neutron monitoring.
- Demonstrating an understanding of gamma spectroscopy and calibrating a HRGS using source data from a library file.
- Demonstrate the ability to carry out 'bare metal' programming on an instrument.

You will also complete a self-study guide 'Cyber Security Awareness'. The self-study guide is something you complete at your own pace and covers the following modules.

Cyber Security Awareness

- Operational security for control systems.
- Differences in deployments of control systems.
- Influence of common IT components on control systems.
- Cybersecurity for control systems.
- Cyber security within IT and control system domains.
- Cybersecurity risk.
- Current trends (threats and vulnerabilities).
- Impacts of a cybersecurity incident.
- Attack methodologies.
- Defence-in-depth security solutions for control systems.

Team Placements

During the project modules you will gain experience of not only the work that is performed under the banner of Control Systems, but also the working environments around site. It also gives the SL staff running the apprenticeship a chance to identify your strengths or weaknesses in relation to a particular technology or type of work. This allows them to make an informed decision about the best department and team for you to be assigned to following completion of the project modules. This determination will be overridingly based on business need, but will also take in to account your strengths, weaknesses and aspirations.

Once allocated to a team, you will continue to build up evidence against the current apprenticeship standard, but the work becomes more real and focused. You will establish a network of colleagues within your team who will coach you in the specific type of work they do, the customers they work with and the working environment this happens within.

If all goes according to plan you, will complete your level 5 and level 6 apprenticeship within this team, remaining with the team as an engineer and integral member of that team. However, if you need to go on secondments to other teams, or it is decided the team placement is not correct for you, the team placement may be changed within your apprenticeship.

After Your Apprenticeship

Your development doesn't end when your apprenticeship does. Ongoing career development is something you should aspire to. Professional registration is something that underpins that career development. You are all encouraged to join the Institute of Engineering and Technology (IET)[1]. You will initially join as a Student member but your long term goal should be a full Member of the IET (MIET) and to be recognised as a Chartered Engineer (CEng.), ultimately you could become a Fellow of the IET (FIET).

The designation of CEng., is a professional registration awarded by the UK Engineering Council[2]. The council will only register individuals who are members of a professional institute such as the IET. Prior to being registered as a CEng., there are two other categories of professional registration that you should obtain.

- Engineering Technician (EngTech).
- Incorporated Engineer (IEng).

For more information on how you join the IET and then register with the Engineering Council please visit their website. The third edition of the 'UK Standard for Professional Engineering Competence (EngTech, IEng and CEng)' can be found at the Engineering Council's website or by following the link below.
http://www.engc.org.uk/engcdocuments/internet/Website/UK-SPEC%20third%20edition%20(1).pdf

[1] https://www.theiet.org
[2] https://www.engc.org.uk/

Foundation Degree in Plant Engineering

To support the apprenticeship standards you will study for a Foundation Degree in Plant Engineering on day release during the first three years of your apprenticeship. The foundation degree is aligned to the *calendar* year. Depending on your apprenticeship pathway you will study one of five academic pathways. All academic pathways will include core engineering modules including mathematics, mechanical engineering, electrical engineering and plant based learning. Other modules will be dependent on the academic pathway. As an apprentice on the Control Systems pathway you will follow the **control and instrumentation** academic pathway.

Full details of the Foundation Degree can be found in the Gen2 Higher Education Prospectus (page 40).
http://www.gen2.ac.uk/wp-content/uploads/2018/10/HE-Portfolio-Jul-final-pages-low-res-Oct-18.pdf

This is an extract showing the courses:

Year 1

Semester 1	Semester 2
PLEN4013 Maths for Plant Engineering & Technology I - Compulsory (10 credits)	PLEN4002 Maths for Plant Engineering & Technology II (10 credits) - Compulsory
PLEN4003 Fundamentals of Mechanical Science - Compulsory (20 credits)	PLEN4011 Fundamentals of Nuclear Science & the Nuclear Industry OR PLEN4010 Engineering & Process Measurement (20 credits)
PLEN4004 Electrical & Electronic Principles - Compulsory (20 credits)	

Year 2 - (Instrumentation & Control Pathway)

Semester 1	Semester 2
PLEN4009 Electronic Instrumentation & Sequence Control- (20 credits) - Option	PLEN5015 Computer Control (20 credits) - Compulsory
PLEN4007 Plant Based Project Management (10 credits) - Core	PLEN5008Plant & Process Control (20 credits) Compulsory
PLEN4006 Plant Based Learning 4 Core (10 credits)	

Year 3 - (Instrumentation & Control Pathway)

Semester 1	Semester 2
PLEN5001 Plant Based Project Core (20 credits)	
PLEN5019 Engineering Design (20 credits) Compulsory	
PLEN5003 Condition Monitoring & SQA (10 credits) Compulsory	PLEN5002 Further Maths for Plant Technology & Modelling (10 credits) Compulsory
PLEN5014 Smart Instruments & Networks (20 credits) Compulsory	

Honours Degree in Plant Engineering

After the foundation degree you will study for an Honours Degree in Plant Engineering on day release during the last two years of your apprenticeship. The honours degree is also aligned to the *calendar* year. As with the foundation degree there are a number of academic pathways. Control Systems apprentices continue with the **control and instrumentation** academic pathway.

Full details of the Honours Degree can be found in the Gen2 Higher Education Prospectus (page 54).
http://www.gen2.ac.uk/wp-content/uploads/2018/10/HE-Portfolio-Jul-final-pages-low-res-Oct-18.pdf

This is an extract showing the courses:

Year 1 - (Instrumentation & Control Pathway)

Semester 1	Semester 2
PLEN6001 Plant Automation (20 credits) - Compulsory	PLEN6011 Mechatronics & System Interfacing (20 credits) - Compulsory
PLEN6002 Plant Design & Simulation Compulsory (20 credits)	
PLEN6006 Plant Control Engineering Compulsory (20 credits)	

Year 2 - (Common Project Module)

Semester 1	Semester 2
PLEN6003 Industrial Project (40 credits) - Core	

Help & Support

During the PEO you will be assigned a Gen2 mentor to help with any issues which may arise during the PEO. Upon completion of the PEO element of the apprenticeship, you will be allocated a professional mentor and a scheme mentor.

Your **professional mentor** will be a Chartered Engineer (CEng) or Incorporated Engineer (IEng) who has completed a mentor training course. Their role is to help identify professional development opportunities and encourage your pursuit in engineering and technology whilst you work toward professional registration. They will help ensure you have appropriate experience to satisfy the requirements for EngTech after completion of the level 5 apprenticeship, and for IEng after completion of the level 6 apprenticeship. This relationship may continue after completion of the apprenticeship.

Your **scheme mentor** is someone who has been through an apprenticeship themselves and is familiar with gathering competency evidence against an apprenticeship standard. They will also have experience of part-time study. They will help you overcome any challenges associated with satisfying the requirements of the apprenticeship standard, and will also offer advice about how to deal with any issues with your studies.

When you join your team placement, you will also be allocated a **buddy**. Your buddy will be a colleague within your team who you see most days. They are there to help you settle into your team and to offer help and advice about any concerns that arise in your placement. Your relationship with your buddy is confidential, so you may choose to ask them for advice on any personal issues that are affecting you too.

If you are struggling with your academic studies on the foundation or honours degree, please raise with Gen2, your mentor or line manager. Gen2 set up additional lessons and sessions to help students and there are many people within Sellafield Ltd who have successfully passed the honours degree, often people in your own team.

Contacts

Sellafield Limited Contacts:

- Clare Bone – Degree Apprenticeship Scheme Owner.
- Cheryl Ireland – Degree Apprenticeship Coordinator.
- Barry Sullivan – Control Systems Pathway Lead.
- Antony Stainton – Control Systems Coordinator.