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 ten pathways, each focusing on a specialism within the overall apprenticeship.

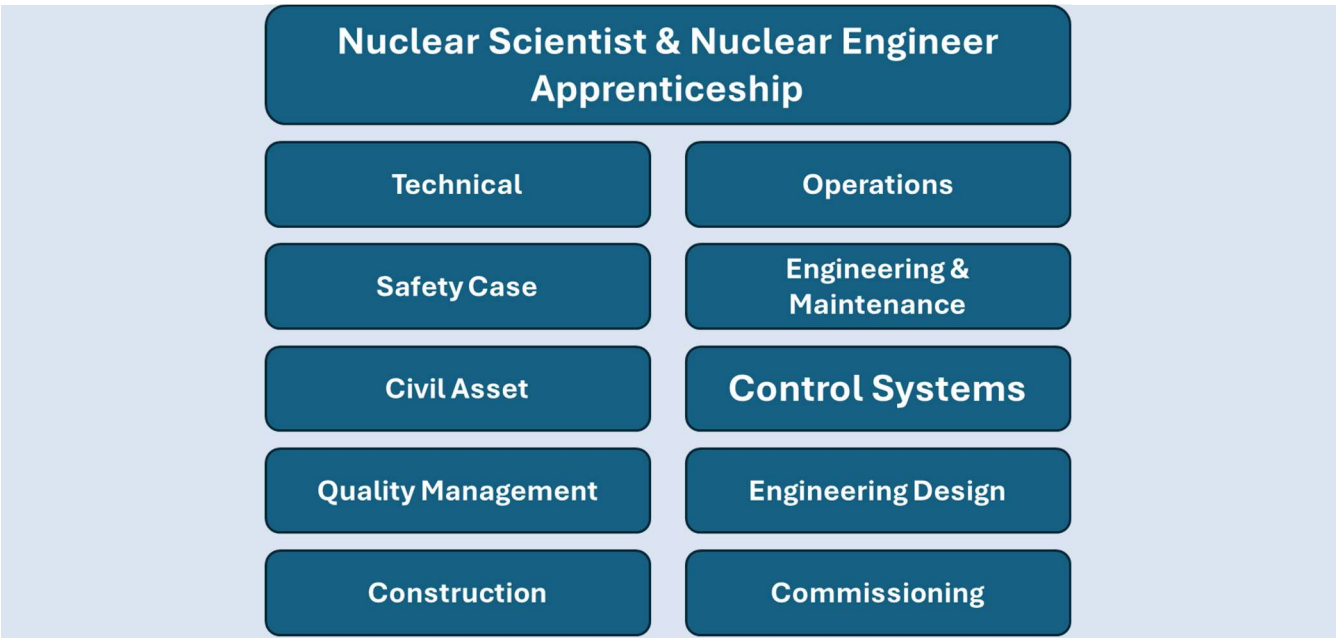

Figure 1: Pathways of the Nuclear Scientist and Nuclear Engineer Apprenticeship

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 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 several 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** or an **HNC/HND in Engineering**, and in the final two years you will study for an **Honours Degree in Electrical Engineering**.

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 at Grades 9 to 4 (Grades A* to C) including Mathematics, English Language and one Science or Engineering subject.
- Minimum of 96 UCAS points at A-Level / T-Level, STEM subjects preferred (e.g. Mathematics, Chemistry, Biology, Physics or Science) but not mandatory.
- Other Level 3 STEM qualifications may be considered.
- Vocational equivalents at level 3 or higher will also be considered as equivalent to UCAS points.
- If you do not have Mathematics at A-Level, then you must achieve a minimum of Grade 6 (Grade B) at GCSE.
- Functional Skills Level 2 will also be considered as equivalent to GCSE Grade 4 (Grade C). Other equivalent qualifications may be considered.

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

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.

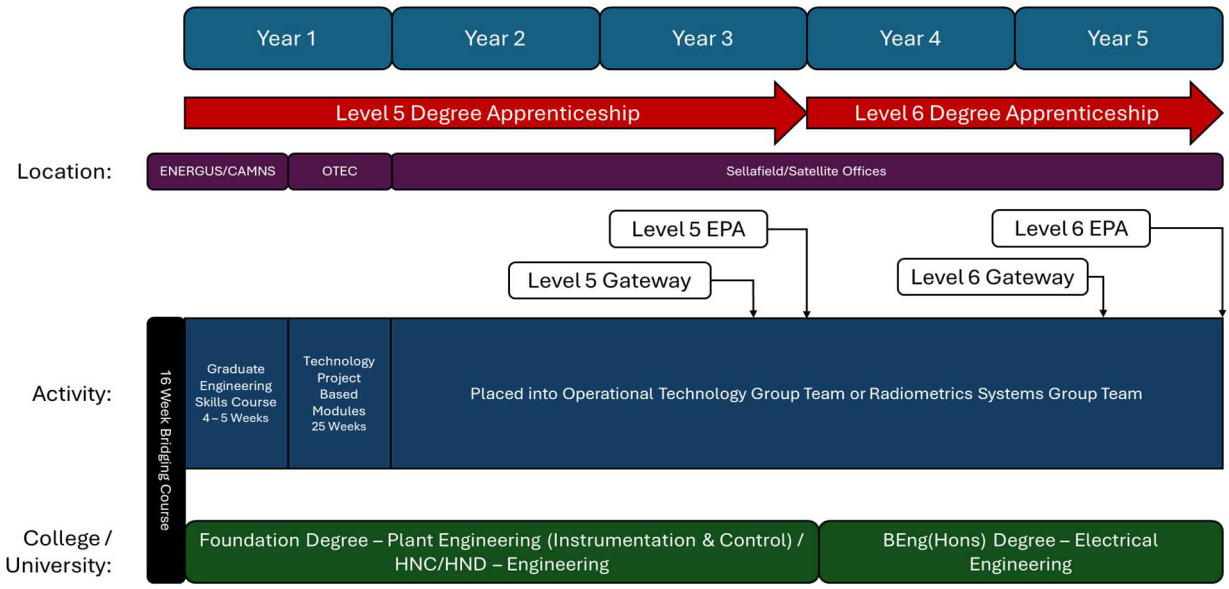

Figure 2: Control Systems Pathway Overview

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 Sellafield Ltd 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.

Engineering Skills Course

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 undertake a Graduate Engineering Skills Course at either Energus or CAMNS for 4 – 5 weeks first. 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 Engineering Skills Course will cover the following topics:

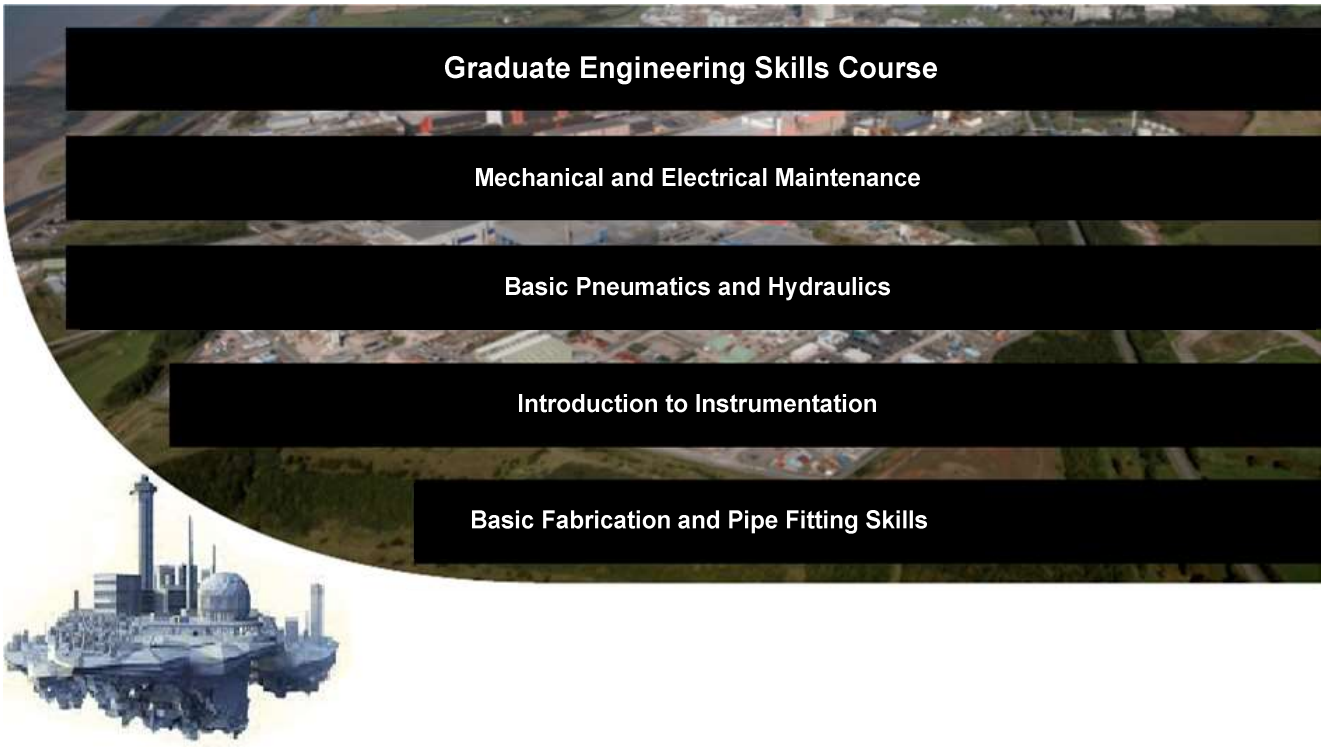

Figure 3: Structure of Graduate Engineering Skills Course

.

Technology Based Project Modules

Once the Engineering Skills Course has finished you move to the Sellafield site or outlying offices, e.g., Unit 18 (OTEC), Leconfield in Cleator Moor to complete a number of technology and procedural based modules. Each technical module lasts 2 weeks followed by 1 week of core control system skills and 1 week of system modification. The content of each is summarised below. Following completion of the modules you will complete a final 6 weeksproject, which will be a culmination of everything you have learned so far. The modules 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.

Introduction to MOD300 DCS (TT0120)

Illustrate DCS architecture and describe the functionality of hardware node types.
Demonstrate the features of the MOD300 and navigation around operator displays.
Produce a hardware configuration item detailing the hardware components within the DCS cabinets. Configure addresses and power up the systems and nodes onto the network
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).
Design, implement and test software to control a Process Control Rig
Explain the difference between the legacy MOD300 system and the latest DCS offerings from DCS vendors, and the differences in configuring modern platforms.

Introduction to IPES and MIS (TT0121)

* Assemble and configure an IPES system based on a Raspberry Pi
*Program an IPES system using Python on a Raspberry Pi
*Interface an IPES system with electronics
*Create and prove a viable disaster recovery plan
*Present users with information about various measurements taken from a Raspberry Pu using the Sensor HAT
*Construct and demonstrate interface code in Python to accept data from a Raspberry PI and store in an MIS
*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 datafiles previously created
*Construct simple Create, Replace, Update and Delete modules to interact with the database tables
*Install and configure Microsoft SQL Server then use SQL Server Management Studio to create an application database.

Introduction to Networks and Operating Systems (TT0124)

*Learn about Virtual Machines
*Install and configure client and Server Windows Operating System
*Apply secure build configuration to client and server operating systems
*Apply malware protection to client and server operating systems
* Assign appropriate subnets to separate out the various zones and allocate IP Addresses to devices within each zone.
* Assign appropriate VLANs to appropriate switch ports.
* Configure a switch using PuTTY and connect PES elements.
* Configure firewalls to facilitate secure communication between PES elements
* Configure a Network Monitoring Station to gather health information about the various control system elements
* Devise a complete validation test to check if a URS has been met.

Introduction to Ladder Logic & SCADA (TT0122 & TT0379)

*Demonstrate an understanding of the standard hardware components of Rockwell 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 Rockwell 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 Rockwell 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.

Core training

*Demonstrate an understanding of configuration management
*Demonstrate an understanding of Requirements, Design, Testing and Installation, being able to explain the purpose of each
*Identify the different stages of an eSMR and what is required to progress (e.g., Documentation, reviews, approvals)
*Demonstrate the ability to perform a simple modification utilising eSMR
*Complete Systematic Approach to Fault Finding
*Gain a basic understanding of instrumentation

Final Project

*Receive and analyse the requirements for the project from your customer
*Follow the V-model software design lifecycle to design, implement and test a product that meets these requirements
*Demonstrate the product to your customer at a Customer Acceptance Test (CAT)

A **Cyber Security** week long module will be provided by Amentum at the end of the final projects.

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 overrulingly 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.

Foundation Degree in Plant Engineering (Instrumentation & Control)	
Level 4 Modules	
Module No.	**Module Title**
PLEN4103	Fundamentals of Mechanical Science
PLEN4104	Electrical & Electronic Principles
PLEN4109	Electronic Instrumentation & Sequence Control
PLEN4111	Fundamentals of Nuclear Science and Technology
PLEN4114	Applied Mathematics for Engineering & Science
PLEN4115	Fundamentals of Project Management in the Workplace

Level 5 Modules	
Module No.	**Module Title**
PLEN5108	Plant & Process Control
PLEN5114	Smart Instruments & Networking
PLEN5115	Computer Control
PLEN5119	Engineering Design
PLEN5129	Further Mathematics for Engineering & Science
PLEN5135	Engineering Design

HNC/HND in Engineering

To support the apprenticeship standards, you will study for an HNC/HND in Engineer on day release during the first three years of your apprenticeship. The HNC/HND is aligned to the *calendar* year. The HNC provides a broad foundation at a level equivalent to the first year of a university degree, while the HND is a more advanced qualification, at a level equivalent to the second year of a degree and includes more specialist units. HNC (Higher National Certificate), a Level 4 qualification providing a broad understanding of engineering principles and practical skills. HND (Higher National Diploma), a Level 5 qualification that builds on HNC knowledge, offering more specialised and in-depth learning.

HNC Level 4 Modules		
Module No.	**Module Title**	**Year**
1	Engineering Design	2
2	Engineering Maths	1
3	Engineering Science	1
4	Managing a Professional Engineering Project	2
33	Fundamentals of Nuclear Power Engineering	2
15	Automation, Robotics and Programmable Logic Controllers (PLCs)	2
16	Instrumentation and Control Systems	1
19	Electrical and Electronic Principles	2

HND Level 5 Modules		
Module No.	**Module Title**	**Year**
34	Research Project	1
35	Professional Engineering Management	1
39	Further Mathematics	1
49	Lean Manufacturing	2
41	Distributed Control Systems	2
42	Further PLCs	1
45	Industrial Systema	2

Honours Degree in Electrical Engineering

After the foundation degree or HNC/HND you will study for an Honours Degree in Electrical Engineering on day release during the last two years of your apprenticeship. The honours degree is also aligned to the *calendar* year.

Below are the modules you study at Lakes College.

Honours Degree in Electrical Engineering	
Level 6 Modules	
Module No.	**Module Title**
NUCL6023	Microprocessor Control
NUCL6004	Robotic Systems, Configuration & Programming
NUCL6000	Professional Development
NUCL6013	Industrial Based Dissertation

Help & Support

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:

- Des Morris – Degree Apprenticeship Scheme Owner.
- Katherine Messenger – Degree Apprenticeship Lead.
- Natalie Parker – Control Systems Pathway Lead.
- Kevin McAdam – Control Systems Coordinator.
- Owen Scott – Control Systems Coordinator Support.