End-point Assessment Plan

Process Automation Engineer Non-Integrated Degree Apprenticeship

Level 7

Contents List

1. Introduction and Overview

This document is the End-point Assessment Plan (the **Plan**) for the Level 7 Process Automation Engineer Degree Apprenticeship (**PA7**). It provides guidance to apprentices and their employers as to what is expected in terms of End-point Assessment (**EPA**). It also provides terms of reference for both the Higher Education (**HE**) providers and Independent Assessment Organisations (**IAO**) involved.

The objective of the EPA is assessment, at the end of the apprenticeship, of the Knowledge, Skills and Behaviours (**KSB**) developed throughout the apprenticeship, the relevant KSBs being articulated in the Process Automation Engineer Degree Apprenticeship Standard (the **Standard**). Performance in the EPA will determine the classification for the apprenticeship: that is Distinction, Merit, Pass or Fail.

The EPA consists of:

- a Presentation based on a substantive piece of work in the workplace, and
- an Interview underpinned by a Portfolio.

The EPA will be conducted by a panel of two experts, one of whom will be an independent chair who will make the decision on the grade awarded.

PA7 has been aligned, as far as is practicable, with the requirements of the UK Specification for Professional Engineering Competencies (**UK-SPEC**). When appropriate, the EPA will also be used to assess suitability for Chartered Engineer (**CEng**) status. That is explained further in Section 6 on professional body recognition.

Note that whilst the EPA determines the classification for the apprenticeship, the outcome of assessment for CEng status is binary: either accept (satisfies the criteria) or reject.

The EPA must be delivered by an approved IAO that is on the Education & Skills Funding Agency's (**ESFA**) Register of Apprentice Assessment Organisations (**RoAAO**).

Delivery of the PA7 package leading up to and including the EPA will be as depicted in **Figure 1** below.

All apprentices must undertake employment based jobs, tasks, projects, etc, referred to collectively as workplace assignments. These shape and are shaped by the Competency Profile and their outcomes feed into the Logbook of Experience and the Archive of Evidence. The Competency Profile, Logbook and Archive are collectively referred to as the Portfolio. The Portfolio underpins the EPA interview so must be in place before the Interview can be held.

Each apprentice must be assigned an industrial mentor to support the process of determining and monitoring the acquisition of KSBs through the workplace assignments and development of the Portfolio. The role of the mentor is detailed in **Annex A**.

In parallel to the workplace assignments, apprentices also undertake an MSc degree in process automation which is worth 180 UK credits (90 ECTS credits). The MSc must be accredited for further learning to Master's level under UK-SPEC for graduates with an accredited first degree. Consisting of taught modules and an Industrial Project, there is normally an upper limit of 5 years for completion. Any HE provider delivering the MSc must be on the ESFA's Register of Apprenticeship Training Providers (**RoATP**).

The MSc degree must be completed before the EPA can be held.

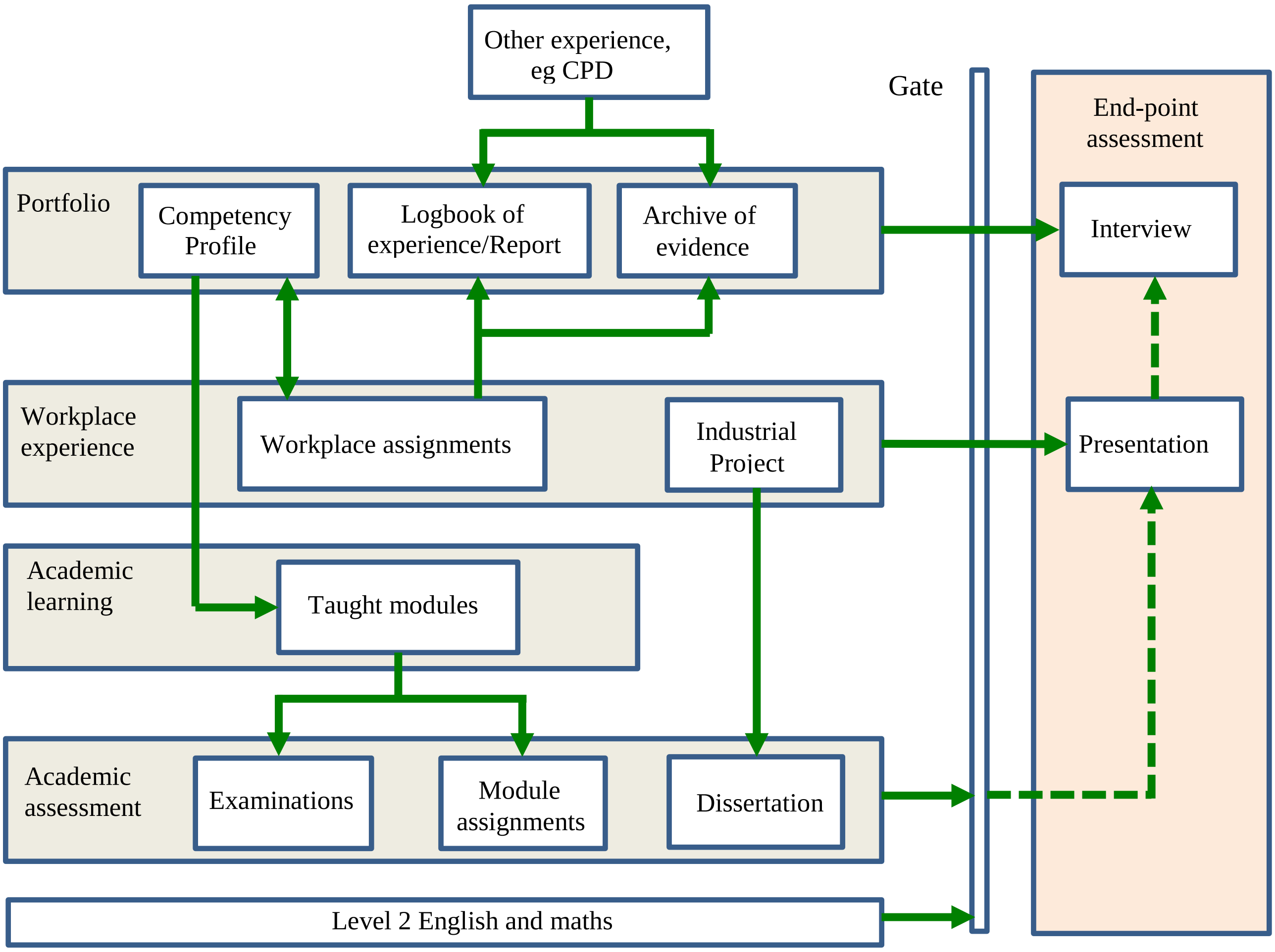

Figure 1

2. End-point Assessment Gateway

2.1 Gateway Requirements

Prior to entering the EPA, the apprentice must have successfully:

- achieved Level 2 English and maths,
- completed an MSc degree in process automation, although the apprentice may not have graduated,
- completed a substantive piece of work in the workplace upon which the EPA Presentation will be based, and
- compiled an up-to-date Portfolio, as detailed below, which underpins the EPA Interview.

The apprentice's employer, who may take advice from the HE provider, will decide whether the apprentice is eligible to enter the EPA or not.

2.2 Portfolio

The Portfolio consists of the Competency Profile, the Logbook and the Archive. It is important that apprentices ensure that there is sufficient emphasis across their Portfolio in the particular requirements of the Professional Engineering Institution (**PEI**) through which they may wish to apply for CEng status.

2.3 Competency Profile

The Competency Profile, 25 pages maximum, is essentially a plan in which, over the course of the apprenticeship, the opportunity to acquire the necessary KSBs is mapped onto the apprentice's work profile. The mapping should be concise enough to enable the Panel at the EPA to quickly establish how the apprentice has acquired the KSBs and provide cross references to the evidence in the Archive to substantiate such.

Guidance on the development and use of a Competency Profile is provided in **Annex B** and an example of a Competency Profile is provided in **Annex C**.

2.4 Logbook of Experience

The Logbook is a 'sort-of' personal diary in the sense that it is a chronological record of the apprentice's work and training over the course of the 5-years of the apprenticeship and of the experience and expertise gained along the way.

Guidance on development of the Logbook is provided in **Annex D**. A typical entry in the Logbook would be as shown in **Annex E**.

Prior to the Interview of the EPA, the apprentice is required to produce a synoptic Report, 10 pages maximum, based upon the content of the Logbook, which provides a reflective overview of his/her self-development over the course of the apprenticeship and identifies areas of expertise and/or experience that require further development. It is essential that the structure and format of the Report be consistent with the PEI's requirements if CEng status is sought.

2.5 Archive of Evidence

The Archive is a repository for documents, diagrams, software, photos, etc, which can be used as evidence at the EPA to substantiate claims made in the Competency Profile and Logbook about KSBs having been acquired. It should be thought of as a virtual wheelbarrow: there is no limit as to what can be put into it, provided that the apprentice has made a non-trivial input to whatever is deposited.

Guidance on development of the Archive is provided in **Annex F**.

3 End-point Assessment

The EPA consists of a Presentation and an Interview, both of which must be passed.

The panel will make holistic assessments of the Presentation and Interview on the basis of the categories of KSBs shown in **Table 2**. Entries will be made in the assessment grid of **Table 3** as appropriate using the grading criteria shown in **Table 4**. Note that the same criteria will be used for both the Presentation and Interview.

3.1 Presentation

The Presentation is prepared and given by the apprentice to the Panel for the EPA. It must be about some substantive piece of work completed in the workplace. The Presentation is an opportunity for the apprentice to:

i. convince the Panel of his/her depth of understanding of the principles, practices, processes and knowhow underlying the application of automation technology in the process industry.

ii. demonstrate his/her grasp of the competencies, breadth of experience and level of responsibility gained during the course of the apprenticeship.

iii. give confidence to the Panel that he/she has acquired the necessary KSBs.

iv. highlight achievements.

The work upon which the Presentation is based could, for example, be:

- of a technical and/or theoretical nature such as in design, development or research.
- of a technological nature as with the implementation of an automation system.
- of a management nature as in the context of a particular project or plant.

The presentation could be based upon the Industrial Project, for which the dissertation for the MSc was submitted, but that is not a requirement.

There is no particular format required for the Presentation but the expectation is that it would be a Powerpoint presentation, perhaps supplemented by simulations, video clips, or whatever other means judged appropriate by the apprentice. Following the Presentation, the Panel may ask questions to seek clarification of competence. It is not feasible to pre-determine these questions: they depend upon i) the nature of the work upon which the presentation is based, ii) what is said in the presentation and iii) what the Panel decides needs to be clarified.

The Presentation and questions will be of 45 minutes maximum duration of which the Presentation itself will be of 20 to 25 minutes.

3.2 Interview

The purpose of the Interview is to assess the apprentice's competence across categories of KSBs as shown in **Table 2**. The Panel will wish to probe, in particular, the depth of understanding, breadth of experience and expertise, and level of responsibility achieved in the course of the apprenticeship.

On the table, and provided to members of the Panel at least 10 working days in advance of the Interview, will be hard copies of the following:

- Competency Profile: version signed by mentor and/or supervisor.
- Report based upon the Logbook.
- Index to the Archive.

The Panel may request, at least 3 working days in advance of the Interview, that specified extracts from the Logbook and/or items from the Archive also be tabled. Demonstration of competence could draw upon items in the Archive other than those tabled.

The Panel will make its holistic assessment of the KSBs acquired by the apprentice by asking questions on five different generic topics to which the answers will necessarily draw upon different subsets of the KSBs. A bank of questions will be developed by the IAO involved. Some typical questions with suggested acceptable responses are provided in **Annex G**.

The Panel may wish to ask supplementary questions to:

i. clarify any responses to questions.

ii. clarify any issues arising from the Competency Profile and Report and confirm that they are a true account of the apprentice's training and experience.

iii. explore particular areas of the work done by the apprentice, including what was done and how it was done.

iv. confirm that the content of the Portfolio is the apprentice's own work, other than that identified in the Index to the Archive as being otherwise.

The Interview will be conducted on the same day as the Presentation, either immediately or shortly afterwards, by the Panel. It will normally involve the Panel and the apprentice alone although, for Quality Assurance (QA) purposes, there could be a witness present.

The Interview will be of 45 minutes maximum duration.

4. Arrangements for the EPA

One or more IAOs may be approved to deliver the EPA. It is a requirement that the delivery be as defined in this Plan with measures of independence as described in **Table 1**.

4.1 Organisation of EPA

The timing of the Presentation and Interview will depend upon circumstances. The cost of the EPA is not trivial so it makes sense to collect together a few apprentices ready for the EPA and conduct them on the same day. The EPA will normally be conducted within a maximum of 4 months of the EPA having been entered.

The venue for the EPA will depend upon what is most convenient for both members of the Panel and apprentices. It could be hosted by a company, an HE provider, a PEI or else held at an IAO's premises.

4.2 EPA Roles and Responsibilities

The Panel for the Presentation and Interview is appointed by the IAO. It will consist of the Chair and one other person, normally an industrialist but could be an academic, as per **Table 1** below. A panel of two experts is deemed necessary to provide coverage of the spectrum of process automation. Note also the possibility of attendance at the Panel of an observer for QA purposes.

Requirements and Role of Panel Members	
Independent technical expert (Chair)	An industrialist, not employed by or closely associated with either the apprentice's company or the HE provider. Must be of CEng status. Must have substantive expertise in process automation and a minimum of 8 years of relevant experience. Makes the distinction/merit/pass/fail decision on the apprenticeship.
Technical expert.	An industrialist, maybe nominated by the apprentice's company. Could be the apprentice's mentor or industrial supervisor. Must be of CEng status. Must have significant expertise in process automation and a minimum of 5 years of relevant experience. Role is to provide advice and act as an observer.
Academic expert.	A lecturer or more senior person, nominated by an HE provider. Could be the apprentice's academic supervisor. Must be of CEng status. Must have significant expertise in process automation and a minimum of 3 years of relevant experience. Role is to provide advice and act as an observer.

Table 1

4.3 Grading and Classification

The Presentation and Interview will assess the categories of KSBs as shown in **Table 2**. These categories have been determined by alignment, as far as is practicable, with the requirements of UK-SPEC for CEng status. The mapping between the categories of KSBs in Table 2 and the UK-SPEC competencies is explained in **Annex H**.

The Chair, in consultation with the other Panel member, will decide upon and make entries (ticks) in the assessment grid of **Table 3** as appropriate using the grading criteria shown in **Table 4**. This requires an entry in one row for each column.

	PA7 Standard	
Assessment	**Categories of KSBs**	**Ref**
Presentation & Interview	Knowledge: technical	A-I
	Skills: analytical and problem solving	N-Q
Interview	Knowledge: general. Skills: technical and commercial leadership.	J-M R-V
	Behaviour: transferrable skills	W-Z

Table 2

	Presentation		Interview			
Descriptors/KSBs	A-I	N-Q	A-I	N-Q	J-M, R-V	W-Z
Deep/High						
Sound/Normal						
Sufficient/Acceptable						
Shallow/Inadequate						

Table 3

The rules for classification, in descending order of precedence, are as follows:

- if there is any entry in the shallow/inadequate row, then the classification will be Fail.
- if there is any entry in the sufficient/acceptable row, a Distinction cannot be awarded,
- if there are four or more entries in any particular row, then the classification corresponding to that row is awarded as per **Table 4**,
- if there are five or more entries in any two adjacent rows, then the classification corresponding to the row with the most entries is awarded,
- if the entries are uniformly distributed, the classification will be Merit.

In the event of a Fail, the Chair of the Panel will verbally inform the apprentice of the reasons for such and provide written advice as to what aspects of the Presentation and/or Interview need to be improved upon.

Classific'n	Descriptors	PA7 Grading Criteria
Distinction	**Deep** understanding. **High** level of competence.	Can explain, in detail if necessary, key principles, techniques and related knowhow. Demonstrates command of a wide range of technologies and practices. Evidence of KSBs successfully acquired and deployed in a wide range of contexts, some of which are complex and/or non-routine. Answers to questions are correct and insightful. Has significant personal autonomy and responsibility. Evidence of substantial project management experience and team leadership skills. Can develop others' KSBs. Communication is lucid (clear, concise, complete, coherent and consistent). Evidence of ability to make sound and informed engineering judgements in open-ended situations.
Merit	**Sound** understanding. **Normal** level of competence.	Can explain key principles, techniques and related knowhow. Demonstrates command of relevant technologies and practices. Evidence of KSBs successfully acquired and deployed in a wide range of contexts. Answers to questions are correct and appropriate. Has personal autonomy and responsibility. Evidence of significant project management experience and team leadership skills. Can develop others' KSBs. Communication is lucid (clear, concise, complete, coherent and consistent). Evidence of ability to make sound and informed engineering judgements.
Pass	**Sufficient** understanding. **Acceptable** level of competence.	Is familiar with key principles, techniques and related knowhow. Demonstrates grasp of relevant technologies and practices. Evidence of KSBs successfully acquired and deployed in standard and routine contexts. Answers to questions are correct. Has some personal autonomy and responsibility but only limited project management experience. Communication is effective. Evidence of ability to make sound engineering judgements in well-defined situations.
Fail	**Shallow** understanding. **Inadequate** level of competence.	Evidence that understanding of key principles, techniques and knowhow is flawed. Demonstrates lack of grasp of aspects of relevant technologies and practices. Evidence of KSBs successfully acquired and deployed but requires supervision and guidance. Answers to some questions are incorrect and/or less than convincing. Has little or no personal autonomy and responsibility and negligible project management experience. Communication is ineffective (may be verbose and lacking in structure). Evidence of ability to make sound engineering judgements lacks credibility.

Table 4

4.4 Resits and Retakes

If either the Presentation and/or the Interview is not passed then the apprentice's employer must decide whether a resit (take the EPA again) or a retake (develop KSBs further before taking the EPA again) is appropriate. If agreed:

- once the issues have been addressed, the apprentice may apply to take the EPA again, normally within 6 months for a resit or 1 year for a retake of the original EPA.
- both the Presentation and the Interview must be retaken, even if one of them was passed originally.

5 Quality Assurance

There are two aspects to **QA**: internal and external.

5.1 Internal QA.

Internal QA refers to the requirements that any IAO involved must have in place to ensure consistent (reliable) and accurate (valid) assessment decisions. The IAO must undertake the following:

- appoint an independent technical expert as Chair of the Panel for the EPA in accordance with the requirements of **Table 1**.
- appoint a second expert, normally an industrialist but could be an academic, also in accordance with the requirements of **Table 1**. Such appointment is to take into account any nominations from the apprentice's company or HE provider.
- produce assessment tools and supporting materials for the EPA that follow best assessment practice.
- provide training for the independent technical experts in terms of good assessment practice, operation of the assessment tools and grading.
- have quality assurance systems and procedures that support fair, reliable and consistent assessment across the organisation and over time.
- operate regular standardisation events that enable the independent technical experts to attend a minimum of one event every three years.
- operate moderation of assessment activity and decisions, through examination of documentation and observation of activity selected on a random basis, typically with a minimum of 10% percent of each independent assessor's assessments moderated.

5.2 External QA.

The purpose of EQA is to ensure that there is a consistency of quality and approach to the EPA, regardless of which IAO is involved and where/when it is carried out. EQA covers all of the IAOs involved in delivery of the EPA. Its focus is upon the Internal QA processes and competence of the IAOs conducting the EPA rather than on the delivery of the apprenticeship itself.

EQA will be employer led. To that end, the intent is that EQA will be carried out by the Engineering Equipment and Materials Users' Association (EEMUA) on behalf of the employers, subject to agreement on costs. EEMUA already has an established QA framework in use for EQA in other contexts and is working towards compliance with ISO 17024.

Development and realisation of EQA will be along the lines of Annex F (Section 6, Points 1-9) of the 'How to' guide for trailblazers published by the Institute for Apprenticeships (IfA) in April 2017.

6 Professional Body Recognition

The Standard and the Plan are aligned, as far as is practicable, with the requirements for CEng status.

Award of CEng status is governed by ECUK. Generic criteria are defined in UK-SPEC published by ECUK. There are academic criteria as well as requirements for relevant experience and responsibility, all of which have to be satisfied.

In essence, for any apprentice with an accredited first degree, typically a BEng with a minimum of 2.2 Hons, the academic criteria are satisfied by the award of an MSc degree that is accredited for ‘further learning to Master’s level’ under the UK-SPEC guidelines. The Standard requires completion of such an MSc degree in process automation as part of the apprenticeship.

Assessment of experience and responsibility is delegated by ECUK to the PEIs. It is important to appreciate that there are differences in approach and substantive nuances in emphasis between the PEIs. The Plan is nevertheless consistent with the expectations of the PEIs. Thus each apprentice must be assigned a mentor. A Competency Profile is developed and maintained. A Logbook is kept about competencies acquired, experience gained and responsibility achieved. A reflective Report is produced based upon the Logbook. There is a Presentation and an Interview.

The intention is that the EPA, when appropriate, will be used for the dual purpose of assessing both the outcome of the apprenticeship and determining eligibility for CEng status. It is essential that the Report, based upon the Logbook, has the structure and format prescribed by the relevant PEI.

Apprentices aspiring to CEng status will need, prior to the EPA, to apply to become a Member of the PEI most relevant to the discipline of his/her first degree and to submit the Report. Membership of any PEI incurs an annual fee.

In the event of an apprentice successfully completing the apprenticeship but being deemed not eligible for CEng status, the apprentice would normally be i) advised by the PEI as to what additional experience and/or responsibility would be required and ii) given the opportunity to reapply at some appropriate time in the future.

7. Implementation

Affordability

The EPA, including EQA, will not cost more than 7.5% of the maximum of the funding band 15 assigned to the PA7 apprenticeship.

Enrolment

The companies that committed to the EoI anticipated 18-26 starts per year. Extrapolating across the sector, it is not unreasonable to predict some 40-50 starts per year.

HE Provider

One university is already delivering an appropriate MSc degree in process automation and has committed to being an HE provider.

IAOs

It is expected that appropriate PEIs will apply to become IAOs for this Standard. Because of their involvement in assessment for CEng status, they should already have established tools, processes and procedures that can be adapted for EPA purposes.

Acronyms

CEng	Chartered Engineer.
ECUK	Engineering Council of the UK.
EEMUA	Engineering, Equipment and Materials Users' Association
EoI	Expression of Interest.
EPA	End-point Assessment.
EQA	External Quality Assurance
ESFA	Education & Skills Funding Agency.
HE	Higher Education.
IAO	Independent Assessment Organisation.
IfA	Institute for Apprenticeships
IChemE	Institution of Chemical Engineers.
IET	Institution of Engineering and Technology.
InstMC	Institute of Measurement and Control.
KSB	Knowledge, Skills and Behaviours.
PA7	Process Automation Engineer Degree Apprenticeship
PACT	Partnership in Automation and Control Training.
PEI	Professional Engineering Institutions.
P no	Portfolio number.
QA	Quality Assurance.
SME	Small to Medium sized Enterprise.
RoAAO	Register of Apprentice Assessment Organisations.
RoATP	Register of Apprenticeship Training Providers.
UK-SPEC	Specification for Professional Engineering Competencies.

Annex A

The Mentoring Role

At the start of the apprenticeship, each apprentice is assigned an industrial mentor by his/her employing company. The mentor is key to the apprentice's progression throughout the apprenticeship. The mentor will provide steerage to the apprentice: that is, take an active part in the monitoring of the acquisition of the necessary KSBs, provide advice and guidance on career direction, and act as the apprentice's champion within the company.

The mentor is required to be a person of CEng status or equivalent who is knowledgeable about process automation and familiar with the nature of the apprentice's work. The mentor may be the line manager of the apprentice but that is not necessary. Inevitably there will be occasions when it is necessary to change an apprentice's mentor: such changes should be kept to a minimum.

The mentor has a particular interest in the apprentice's Competency Profile and Logbook. The Competency Profile is a plan for acquisition of the KSBs, each of which is signed off by the mentor when, in his/her professional judgement, the apprentice i) is able to demonstrate the attributes of the KSB, ii) has credibly and succinctly described the relevant experience and expertise in the Logbook, and iii) can provide evidence to support acquisition of the KSB that can be put in the Archive.

The expectation is that the mentor will formally meet the apprentice at least bi-annually, ie 6 monthly, to review progress, etc. The meeting is formal in the sense that the mentor makes a written record of the main points of discussion and whatever outcomes/decisions are agreed. That record is central to the QA monitoring of the apprenticeship. The record of the meeting should be made available to the apprentice in a timely way and will be saved in the apprentice's Archive.

Note that once the Industrial Project of the MSc has started, if the mentor does not become the industrial supervisor for the project, the mentor may hand over the mentoring and QA role to the supervisor. This recognises that the supervisor is likely to have more contact with the apprentice and be in a better position to provide advice: however, the handover is not a requirement. Also the formal meeting frequency should become quarterly with the focus on i) successfully finishing the project, ii) ensuring the Competency Profile is finalised and iii) checking the Logbook is up to date and the Archive is complete.

Prior to the Interview of the EPA the mentor and/or supervisor are required to countersign:

i	a hard copy of the Competency Profile as confirmation that they have indeed initialled the individual KSBs as indicated.

ii.	the index to the Archive to confirm that the works declared as being attributable by the apprentice to him/herself is correct.

Annex B

Development of Competency Profile

The Competency Profile, 25 pages maximum, involves the mapping of an apprentice's work profile onto the KSBs of the Standard. That mapping is particular to the apprentice according to his/her job function and role, the projects with which he/she is associated and the tasks to be done. At the end of the apprenticeship, all 26 of the KSBs should have been acquired: some through academic study, further Continuing Professional Development (**CPD**) and private study, and the rest through the Industrial Project and workplace experience, each hopefully reinforced by the other.

KSBs, when acquired, will be signed off (initialled) by the mentor at the bi-annual meetings between apprentice and mentor. The grading of KSBs is a binary decision: either the KSB in question has been acquired or it hasn't, either it has been described in the logbook or it hasn't, either the evidence exists in the Archive or it doesn't.

The Competency Profile may be maintained in electronic format, carefully backed up, but hard copy will be required for the EPA. The whole Competency Profile will need to be signed off by the mentor and/or supervisor prior to the Interview of the EPA as confirmation that the KSBs have indeed been acquired.

Initial Competency Profile

It is inconceivable that, at the outset, the apprentice will be able to develop a Competency Profile for all five years of the apprenticeship because, inevitably, jobs, roles and projects all change. The Competency Profile, therefore, is a living document: initially it will be sparse but will evolve and become complete over the course of the apprenticeship. At best, as a plan, it will be reliable for the next 6-12 months.

At the start of the apprenticeship, based upon the apprentice's understanding of his/her work profile, he/she will identify which KSBs there will be the opportunity to acquire in the workplace. The apprentice will also identify the first few modules of the MSc to take according to academic background, work requirements, career aspiration, etc, which will enable other KSBs to be identified.

This initial version of the Competency Profile will be developed in conjunction with the apprentice's mentor. The role of the mentor is to offer guidance whilst at the same time ensuring that the mapping is both realistic and appropriate from the employer's perspective. Agreement on the initial version shall be the principal outcome of the first bi-annual meeting.

Structure

The Competency Profile will consist of a table structured as shown in **Annex C** which includes some typical entries. The table will articulate all 26 of the KSBs as per the Standard with the appropriate A-Z identifier. Entries in the table will identify, for each KSB, how and when it was acquired: that is by means of:

- MSc module,
- workplace assignment (which plant/which project/what tasks),
- Industrial Project,
- further CPD, other training (either internal or external provider) and self-study,

together with the relevant dates/periods and cross references with Portfolio numbers (**P no**) to evidence in the Archive.

It is expected that there will be multiple entries for most KSBs, each having been acquired and reinforced by several means during the apprenticeship.

Use of Competency Profile

To a large extent the Competency Profile provides the basis for the bi-annual meetings between the apprentice and mentor, the objective being to:

- review current progress and plan for future acquisition of KSBs.
- update and expand the Competency Profile in the light of experience and changing jobs/projects.
- determine which modules of the MSc degree need to be taken for KSB purposes in the light of employment needs.
- identify needs for additional CPD/training, either internal or external, necessary both for 'doing the job' and acquiring further KSBs.
- identify other opportunities for gaining exposure to KSBs not covered by the above.
- explore what changes in job function/project type may be necessary to acquire the complete set of KSBs.

Some 3 years into the apprenticeship, the bi-annual meetings will additionally need:

- to start the process of identifying an appropriate Industrial Project and consider which KSB's it will enable the apprentice to acquire.

Once the Industrial Project has begun, the quarterly meetings between apprentice and mentor and/or supervisor will need:

- to review progress of the project and confirm that it is indeed delivering on the KSBs anticipated.

Annex C

Competency Profile for ______________________

Level 7 Process Automation Engineer Degree Apprenticeship							
Iden	**KSB**	**MSc module**	**Workplace assignment or Industrial Project**	**CPD, other training or self study**	**Date/ period**	**P no**	**Mentor initials /date**
Knowledge: technical							
A	Knows the principles of design and operation of a variety of unit operations and the principal features of construction of related items of process plant.	**i**. Chemical Engineering Principles, PA/232, Jan 2017 **ii**. Batch Processing & Automation, (planned)	**i. Gunge distillation unit upgrade**. Interacted with plant management to understand operability issues, plant mods & timing constraints prior to committing effort to spec'n work. Made notes of mtgs (**P10**).	Read parts of Chapter 11 of Vol 2 Chemical Engineering (Coulson & Richardson).	April 20xy	P10	
			ii. Mogam paste plant. Involved in commissioning of batch reactor, charge vessels, pressure filter, related pumps, exchangers & pipework. Initiated works order (**P21**) for mods to external circulation loop and updated P&ID (**P22**).	…	July – Aug 20xy	P21 P22	
B	Understands a range of relevant strategies and techniques for the control of both batch and continuous plant, and the knowhow for translating them into designs.	**i**. Control Schemes & strategies, PA/225 May 2016 **ii**. Dynamics & Control of Distillation	**Gunge distillation unit upgrade**. Specified mods to control scheme to incorporate slave loops and apply internal reflux control to get around sub-cooling problem. Revised P&I diag (**P11**) and wrote the control narratives (**P12**).	Read relevant sections of Chapter 12 in Process Control (King) and Chapter 35 in PA Handbook (Love).	May – June 20xy	P11 P12	

		Columns (planned)					
…	…	…	…	…	…		
F	Is familiar with the essential functionality of the real-time languages, structures and tools provided for the development of application software for at least one ICCS or equivalent.	Control Systems Technology, PA/238, July 2017, (booked).	**Gunge distillation unit upgrade**. Temporarily seconded to app'n s/w support team for Gunge project. Developed and co-authored Functional Design Spec (FDS) (**P13**). Produced function block diagrams **(P14)** for design and implemented mods to control scheme on ConQA dev't system. Wrote test spec (**P15**). Organised change control form **(P16)** to authorise changes to be downloaded to ICCS prior to implementation.	Attended 1-week course at ConQA Co on basic configuration of their ICCS.	Sept - Oct 20xy	P13 P14 P15 P16	
G	Understands the organisation of alarm systems, the need for alarm management and the quantitative analysis and design of Safety Integrity Level (SIL) rated protection systems.	**i.** Control Systems Technology, PA/238. **ii**. Instrum'n & Measure't, PA/228, Sept 2016.	**Mogam paste plant**. Checked colleague's design of interlock on charge vessel overflow (note solvent so also IS requirement). Found a mistake in reliability calculations so had to rework and issue a design modification which pushed the requirements into the SIL2 range (**P20**).	Read through internal company standards on application of IEC 61511 as well as EEMUA guide 222 and relevant sections of Chapters 52, 53 & 56 of PA Handbook (Love).	Nov 20xy	P20	
H	…	…	…	…	…		
I	…	…	…	…	…		

Knowledge: general							
J	Understands the life cycle of control systems in terms of feasibility, specification, design, development, acceptance, installation, commissioning, operation, maintenance and support.	Manag't of Automation Projects, PA/235, April 20yz, (booked).	**Gunge distillation unit upgrade**. Involved in life cycle for mods to control scheme from specification stage through to testing and Factory Acceptance Testing (FAT). Had meetings with Team Leader at each stage to review progress and plan work ahead.	Referred to relevant sections of Chapters 60-64 of PA Handbook (Love).	April - June 20xy Sept - Oct 20xy	P10 P11 P12 P13 P14 P15	
…	…	…	…	…		…	
M	…	…	…	…		…	
Skills: analytical and problem solving							
N	Able to analyse complex automation problems of a process nature, reducing them to their underlying issues, and can synthesise solutions subject to constraints.	**i**. Control Schemes & Strategies, PA/225, May 2016. **ii**. Modelling & Simulat'n, (planned). **iii**. Classical Control Sys Design, (planned).	**Noxious scrubber plant**. Attached to team looking into problems with plant operability when on full load/recycle. Developed first principles model and simulated using Matlab /Simulink (**P30**). Explored different scenarios and found i) recycle pump was constraint and ii) cooler too sluggish. Compiled report (**P31**). Plant Manager activated upgrades (**P32**).	…	Jan - April 20yz	P30 P31 P32	

…	…	…	…	…		…	
Skills: technical and commercial leadership							
R	Able to interpret requirements for automation and can articulate them in terms of user and functional design requirements, testing and acceptance specs, and operating procedures.	Manag't of Automation Projects, PA/235, April 2017, (booked).	**Gunge distillation unit upgrade**. Albeit only a small project, took the lead role in articulating the FDS (basis for the reconfiguration) and the test spec (basis for FAT). … …	… …	Sept - Oct 20xy	P14 P15	
V	…	…	…	…	…	…	
Behaviour: transferrable skills							
W	…	…	…	…	…	…	
X	Works effectively and with enthusiasm as a member of one or more teams, interacting with and supporting other team members, whilst being committed to delivering on agreed targets for deliverables.	…	**i. Gunge distillation unit upgrade**. Albeit only a team of 3 persons, including the part-time Team Leader, there was good team spirit, common purpose, and deliverables all completed on time. **ii. Noxious scrubber plant**. Ditto, except modelling completed ahead of schedule. …	**i.** Attended 2-day in-house 'Project Skills' course. **ii**. Attended 0.5-day in-house 'Teamworking' course.		P31	
…	…	…	…	…	…	…	

Note 1 The Mentor and/or Supervisor shall initial and date each of the KSBs once, in his/her professional judgement, the Apprentice: i) is able to demonstrate the attributes of the KSB, ii) has credibly and succinctly described the relevant experience and expertise in the Logbook and iii) can provide evidence to support acquisition of the KSB that can be put into the portfolio.

Note 2 Whilst each KSB is initialled as and when it is acquired during the course of the apprenticeship, the Mentor and/or Supervisor shall sign off a hard copy of the whole Competency Profile prior to the Interview of the End-point Assessment (EPA) as confirmation that they have indeed initialled the individual KSBs as indicated.

Signature and date: ________________________________ (Mentor)

Signature and date: ________________________________(Supervisor)

Annex D

Development of Logbook

There will be an Introduction to the Logbook which sets the scene, placing the apprentice's company in the context of the industry (supplier, contractor and end-user), the Apprentice's Dept/Group within the company structure (eg Projects Dept, Engineering Support Group, etc) and the apprentice's role within that Dept/Group (eg Control & Instrumentation Engineer, Commissioning Engineer, etc). This may well need to be amended and expanded as the apprentice's circumstances change.

The Logbook has three particular purposes, it is:

i. a chronological and synoptic record of achievements.

ii. a record of observations about and reflections upon experiences and expertise gained.

iii. a means of corroborating and reinforcing the claims made in the Competency Profile for KSBs acquired.

The expectation is not that entries be made in the Logbook on a day-to-day basis but rather from task-to-task, at key stages in a project, when some entity has reached a logical stage or has been sufficiently completed to be able to comment upon. Also, it is not expected that entries are contemporaneous but rather that they are retrospective. As a guideline, there will be 1-2 pages per month which, over the 5-year duration of the apprenticeship, translates into a maximum of some 90 pages.

Entries in the Competency Profile are necessarily terse. The Logbook, however, provides the opportunity to expand upon (but not pad out) those entries by providing some context, explaining the issues in more detail, reflecting (with the benefit of hindsight) upon what could have been done differently or better and, in particular, commenting on lessons learned. Each entry will provide cross references with a Portfolio number (**P no**) to the evidence in the Archive.

The Logbook is personal but not confidential: the expectation is that it will be referred to in the bi-annual/quarterly meetings with the mentor and/or supervisor. There is a requirement that it be made available for inspection by the Panel at the EPA. It is expected that the Logbook will be electronic, carefully backed up, but hard copy of small sections may be requested for the EPA.

Annex E

Example of Entry in Logbook

Date of entry into Logbook: 6th May 20xy	
Plant/Project	Gunge Distillation Unit Upgrade
Period	April 20xy
Summary (as per Competency Profile)	Interacted with plant management to understand operability issues, plant mods & timing constraints prior to committing effort to specification work. Wrote up meetings notes (P10).
KSB	**Relevance to KSB**
A	*Had to get to grips with the basics of distillation units, esp principal features of construction and principles of operation, as a basis for getting my head around the scope of changes required to the control system. Also got a grasp of centrifugal pumps, heat exchangers (condenser and reboiler), steam & CW supply.*
P10	**References to Archive of Evidence**

Retrospective/reflective Commentary
This was my first job since being appointed to work as an Apprentice Process Automation Engineer with Whiffo Corp (UK) Ltd. I took part in preliminary discussions with the Gunge Plant management. There were four meetings over the course of two weeks which included a tour of the relevant section of the plant. Involved in the meetings were variously the Plant Manager, Site Engineer, Quality Manager and the Instrument Supervisor (IS), my Team Leader (TL) and myself. *Not having a chemical engineering background I was very much in listen and learn mode. I did however manage to read parts of Chapter 11 of Vol 2 Chemical Engineering (Coulson & Richardson) which gave me some understanding of the construction and operation of distillation units, so I managed to follow most of the discussion, even if I didn't get to grips with the intricacies of their design. It would have been good to have done the Dynamics & Control of Distillation Columns module before this work but the time scales were all wrong: c'est la vie.* *In essence, the distillation unit has never performed as expected and the management and operations team have had to live with its shortcomings. The basic problem is that the unit seems to be difficult to control and either the top product quality can be achieved but not the distillate flow or vice versa. The latter is characterised by top product quality swinging from one extreme to another over relatively long periods. There are some planned mods to the pipework and pumps (for integrity and reliability reasons) which are unlikely to impact upon performance. They all seemed to think there ought to be scope for improving things by simply changing the way the column is controlled but nobody, except TL, had any idea how.* *Using the key P&I diagram as a basis, there was a wide ranging discussion about operation of the plant. I was impressed by their commitment and willingness to try to understand the issues, especially with how they used the PI system to bring up data to*

either justify or refute arguments. My impression was that the plant management had already decided that they wanted a real-time optimiser but there was a consensus that it would be expensive and that simpler/cheaper options should be explored first.

Of all the options considered, two (both suggested by TL) were agreed to be worth taking further:

● *the plant's utilities, esp steam & cooling water supply pressure, are subject to big and intermittent changes. It was agreed that the control loops which manipulated these utilities should have slave loops installed to reject the disturbances: that is the control loops are to become cascade systems. Apparently this is the norm but was not done at the suggestion of the EPC to save on capital costs: the savings were trivial, and now it will cost a lot more to fix. Goodness knows what it has cost on the quality front. The drift of things was that this is typical of the mindset in Whiffo Projects Finance Dept. IS will identify additional instrumentation requ'd and make an estimate of costs/timescale.*

● *the reflux drum seems to be excessively large, and hence the distillate residence time too, with the potential for significant subcooling of the reflux. It was agreed to i) operate with a much lower level in the drum and ii) to change to an internal reflux strategy. TL committed to planning & implementing reconfiguration of the ICSS and, again, IS will sort out inst'n requirements & costs.*

I felt the fortnight went well and the project seems to have got off to a good start: a specific problem had been reviewed, some credible potential solutions were identified, a way ahead has been planned, I learned a lot about how the interface between plant management and engineering support works, and I managed to learn something about how distillation units work.

I wrote up the meeting notes ***(P10)*** *for the Team records (checked by TL).*

Informed by TL that he wanted me, under his supervision, to take the various actions forward.

Annex F

Development of Archive of Evidence

There is no structure to the Archive other than for its index. Thus each item will be indexed with a Portfolio number. The same P no must be used to cross reference entries in the Competency Profile and the Logbook to items in the Archive. Items should be grouped together in decades according to plant/project as has been illustrated in Annexes B and C. For example:

Gunge distillation unit upgrade:	P10, P11, P12, P13, P14, P15, P16
Mogam paste plant:	P20, P21, P22, …
Noxious scrubber plant:	P30, P31, P32, …

The Archive is virtual in the sense that all items on the index must exist, either electronically or otherwise, not necessarily all in the same place. Hard copy of any item in the Archive must be capable of being produced, upon request by the Panel, in advance of the Interview for the EPA.

Apprentices will inevitably need to deposit items in the Archive that have been partly, or even largely, done or based upon work done by other persons. Inclusion of such items is legitimate provided that the apprentice identifies clearly and unambiguously those parts/work/data/pages etc attributable to him/herself. It is the apprentice's responsibility to declare such, on an item by item basis, in the Index to the Archive. The mentor and/or supervisor is required to countersign such.

Potential Items for inclusion in Archive:

- records of biennial/quarterly meetings with Mentor and/or Supervisor.
- minutes of project/team meetings.
- project reports.

- process flow charts.
- P&I diagrams.
- channel/loop diagrams.

- termination rack layouts.
- wiring & circuit diagrams.
- database tables.

- function block diagrams.
- sequential function charts.
- procedural coding.
- mimic displays.

- user requirements specifications.
- functional design specifications.
- control narratives.

- software test specifications.
- factory acceptance specifications.
- site acceptance specifications.
- modification control forms.

- mass & energy balance calculations.
- SIL related reliability calculations.
- valve sizing calculations.

- control system design & analysis.

- stability calculations.
- dynamic models: first principles.
- dynamic simulation programs.
- steady state & dynamic simulator models.

- costs and benefits analysis.
- cash flow & payback spreadsheets.

- project planning: Gantt charts.

- user guides.
- system manuals.
- in company standards & codes of practice.

- exam papers from the taught modules of the MSc degree.
- marked assignment reports from the taught modules of the MSc degree.
- transcript of results from the MSc degree.
- Dissertation submitted for the Industrial Project.
- confirmation of the award of the MSc degree.

Annex G

Typical Interview Questions

Below are some generic questions typical of those that could be asked at the Interview together with some suggested responses.

Question 1 (Infrastructure and Topology)

KSBs involved: C, D, E, F, Y

I see from your Competency Profile that you were heavily involved in the project for the Gunge distillation unit upgrade. That resulted in the installation of a few additional i/o channels. Can you please outline to me the route taken by the extra channels associated with the slave loop for the cooling water supply to the overhead condenser.

Response. *In fact, for that particular loop, there was only one additional channel which was an analogue input for flow measurement. In the event, a conventional orifice plate/dp cell type of measurement was specified on the grounds of cost. Since this was an upgrade to an existing system, for which most of the rest of the field instrumentation was connected up to the Integrated Control and Safety System (ICSS) by means of a fieldbus network, the same technology (FF) was used for the flow measurement. That meant that the dp cell had to be FF compatible. Also a check had to be made that there were spare segments available in the FF topology to support the flow measurement (and indeed the other additional i/o signals) for which a dedicated spur was assigned. The dp cell takes its power from the fieldbus network so does not need an independent power supply.*

The fieldbus network is itself routed through a Field Termination Panel (FTP) via trunking to a FF interface card which is rack mounted in a dedicated i/o marshalling cabinet in the Local Equipment Centre (LEC). Whilst FF technology enables configuration of the slave loop at device level, Gunge plant policy is that the fieldbus is simply used as an interface to the instrumentation and configuration is done within the ICSS. So the final stage of the route for the flow measurement input channel is scaling, applying engineering units, attaching alarm limits, etc, which is done using the appropriate analogue input function blocks selected from the ConQA system function block library.

Question 2 (Design)

KSBs involved: A, B, F, N, Q, S, W

OK. Staying with the mods to the Gunge unit, can you give me a simple explanation of the changes to the design of the reflux control scheme.

Response*. The basic problem was to do with the size of the reflux drum: the residence time of the distillate was such that, despite the drum being well insulated, the reflux stream was well below its boiling point by the time it left the drum. This was causing excessive condensation of vapours on the reflux plate in the column and affecting the column performance. In the normal course of events, the top product quality (temperature) controller simply manipulates the external reflux flow. However, with internal reflux control, a cascade system is used with the master loop controlling the quality (temperature) and the slave loop manipulating the reflux flow.*

The extra condensation causes the internal reflux flow to be greater than the external reflux. With internal reflux control, the master controller is tricked into manipulating the internal reflux flow as if it were manipulating the external reflux flow (see Figure 35-23). That is achieved by applying a scaling factor to the flow measurement of the slave controller. The scaling factor is based upon an estimate of the amount of condensation *taking place which is calculated from additional measurements of the external reflux flow rate and of the overhead vapour and external reflux flow temperatures. All of that functionality is realised by a combination of function blocks selected from the function block library, configured as appropriate with their underlying data blocks being populated with the relevant values.*

Question 3 (Project Engineering)

KSBs involved: J, K, L, R, S, T, V,W, X

I note from your Competency Profile that you were involved with the Gunge distillation unit upgrade from the outset right through to its conclusion. That often never happens throughout an engineer's whole career so you have been particularly lucky. Can you give me a summary please of your contribution to the various stages of the project's life cycle.

Response. *Yes, indeed, I recognise my good luck and, whilst it was only a very small project, it has given me some valuable insights. Even though I worked for Automation Projects which is part of Whiffo's Engineering Division and the Gunge plant is owned and operated by Whiffo Chemicals, and we are all part of the same company, the project nevertheless had the feel of a contractor/end-supplier relationship to it. Otherwise, there's not much that I can add to what it already says in the Competency Profile.*

My initial involvement was to interact with the Gunge plant management to understand the underlying problems which were of a controllability and operability nature. Whilst there was no costs and benefits analysis or User Requirements Spec (URS) as such, there was a clear commitment by plant management to go ahead with the project. So the initial effort focussed on what mods to make. I produced notes on those meetings and used them as a basis for writing the control narratives. It being an existing plant, there was also a need to update the P&I diagrams which I handled.

Having been seconded temporarily to the Application Software Team, I developed the Functional Design Specification (FDS) for the internal reflux control scheme which was issued under my Team Leader's authority. I then designed the application software: the design was in the form of a fairly complex function block diagram, together with the related underlying data blocks, and various mods to the mimic diagram and group displays. I also checked the data blocks of other related function blocks and found several minor errors which I took the opportunity to correct. That was followed by testing the scheme out on the ConQA dev't system for which I developed a relatively simple test spec. It being an existing plant/control system, it was necessary to organise a Change Control Form (CCF) to authorise downloading of the mods prior to their implementation. Apart from some fine tuning of the loops, the revised scheme worked almost perfectly from the moment it was switched on. It had previously been agreed that a formal Factory Acceptance Test (FAT) was not required. Instead, the plant manager witnessed the internal reflux control scheme working over a period of several days and countersigned the CCF.

Whilst I was largely working on my own and managing myself throughout the project, albeit under the supervision of my team leader, there were nevertheless times when I had to interact with others in the team and on the plant. For example, when I was seeking advice as to how the development tools worked, the database was organised, and in organising the CCF. Support was willingly given and sensible advice provided. The interaction with colleagues was positive and the project satisfying.

Question 4 (Sustainability)

KSBs involved: A, C, J, M, V

In what way does the Gunge distillation unit upgrade contribute to sustainability?

Response. *There are two angles, maybe more, to sustainability: firstly there is that which relates to the world's material resources, environmental issues and so on, and secondly to the sustainability of the business. However, the upgrade project concerned an existing plant. All the major decisions about process route, types of plant items, etc, were historic and, in that sense, there was little scope for the upgrade to have any major environmental impact. Even the options around the slave loop of the reflux flow control scheme were constrained. Given a blank piece of paper it would ideally have consisted of a variable speed drive pump with a non-invasive flow measurement, but the centrifugal reflux pump and pipework already existed so the only cost effective option was an orifice plate and dp cell.*

Nevertheless, sustainability of the business will have been enhanced. Implementation of the cascade strategies to reject disturbances in the utilities resulted in less variance in the controlled variables and hence more effective use of cooling water and steam. I never did any costs and benefits analysis for this but, inevitably, it will have reduced net energy consumption. Also, the internal reflux strategy dramatically improved product quality: not only will that have had a direct impact on overall plant effectiveness but, in particular, it will have reduced the cost of re-processing off-spec product. So there will be significant further energy savings.

The discipline and technology of process automation should be seen as an enabler. It is not the cause of unsustainability issues per-se but a means, often the only credible means, of resolving most (if not all) of them. So, by effective monitoring, control and intervention, they can be managed and mitigated to an acceptable level. I think the Gunge upgrade project demonstrates that to be the case.

Question 5 (Safety Culture)

KSBs involved: C, D, G, I, M, N, O, Q, V, W, X, Z

Question. In your Competency Profile, you referred to the redesign of an interlock for a solvent overflow on the Mogam Paste Plant. Using that as an example, tell me about the safety culture in Whiffo.

Response. *From what I have seen, safety is taken very seriously in Whiffo, both within the Engineering Division and Whiffo Chemicals. Safety certainly has a high profile and a lot of money is spent on it. However, I perceive an overenthusiasm for the mundane slips and trips stuff, the wearing of hard hats, goggles, high vis and so on (even in safe areas!) and am not convinced by the bigger picture. There seems to be a lack of commitment to functional safety which is surprising given that this is the only development of any consequence in the safety arena in the 21st century. But, on reflection, that is perhaps not too surprising as the company is dominated by chemical/process engineers and their understanding seems to go no further than HAZOP and, even if it does extend to LOPA, it comes across as a black box with little understanding of what's going on inside.*

As for the work on the solvent overflow trip, that came about by chance. A process engineer in my office was carrying out a post commissioning safety review of the reactor system for the Mogam Paste Plant. I had been involved in commissioning that section of the plant earlier in the year and took an interest. I just didn't believe him when he said that the solvent trip system only needed to be rated at SIL1. I discussed the situation with my Team Leader and he agreed that I should work on this independently and discretely. I was heavily guided by the relevant chapters of the Process Automation Handbook. In the event, I developed my own fault tree for the top event (overflow) from which I was able to determine the demand rate (DR). I sought independent advice about the potential consequences C(E). Then, using the industry norm of 10^{-5} *deaths /year as the target for Risk, I was able to come up with the PFD for the interlock system which placed it at the top end of SIL2 (not far from SIL3).*

This was a difficult situation to handle and much tact was required. Whilst we share open plan offices, Process Engineering and Automation Projects are different teams, albeit both within Whiffo's Engineering Division. In effect I was covertly re-working the design of a more senior colleague in a different team and challenging his judgement. My Team Leader handled the politics of the situation brilliantly, the bottom line being that the trip system was reclassified as SIL 2 and I have not been ostracised by the process engineers. An important footnote to this is that Whiffo appears to have no credible database of failure modes, rates of failure, etc, for the types of device used in protection systems.

Question 6 (Operability)

KSBs involved: A, M, N, O, (P), V, Y,

I see that you have built a model of the Noxious scrubber plant. Tell me about the background to that and how you went about building the model and, if possible, can you demonstrate the simulation.

Response. *The background was quite simple. The scrubber, which is essentially an absorption column, didn't perform very well when it was on full load and by implication on full recycle. So, at the top end of its operating range, it was not removing as much of the contaminants from its gaseous inlet stream as it should have been. I was tasked with building and simulating a model of this to try to understand what was going on and to make some recommendations. At first it seemed to be rather a daunting task, especially as there seemed to have been no other similar projects done in the recent past with experience to be drawn upon. But once I had begun to get my head around it, I realised that there was essentially only a single unit (absorption column) and various ancillary items: recycle pump (centrifugal), cooler (in the recycle, because the absorption is exothermic), gas supply and vent systems (both fixed so outside scope of model) and controls (simple feedback).*

I chose to build a first principles dynamic model with the variables in deviation form. The model itself was of a distributed parameter nature. Ultimately the model consisted of steady state gains, time lags (characterised by time constants), time delays and various other algebraic functions. The parameters of the model were themselves all characterised by expressions involving process variables (coefficients, physical properties, dimensions, normal values, etc) which were either known, could be measured or for which sensible guesses could be made. The model was translated into Simulink form and run in the Matlab environment.

I chose this particular route for several reasons. At a practical level, Whiffo does not have a licence for a proprietary process simulation package (such as Hysys or UniSim) and I have prior experience of using Simulink/Matlab. But at a more philosophical level, I prefer to develop my own model where I know what assumptions have been made, what its limitations are, etc, rather than using a model drawn from a library that is essentially a black box whose behaviour you just have to accept. I recognise that the black box approach may be more accurate and also, for a large plant, it may be more cost effective in terms of time developing the model but, in this case, we weren't looking for perfection and there was only a single unit.

As I have just demonstrated to you on my laptop, the model shows fairly convincingly that the recycle pump was undersized. The primary recommendation of the study therefore was to double the pump's capacity for which the maximum recycle rate would still be well within the flooding limits of the column. Increasing the recycle rate resulted in a win-win situation. Firstly the column performance improved to the extent that overall separation efficiency came within the original design spec. And secondly, a major bonus, the response of the cooler improved making the unit as a whole more controllable. The latter was due to increased turbulence on the shell side of the cooler (cooling water on the tube side) thereby increasing the overall U value.

Annex H

Mapping between KSBs of PA7 and Competencies of UK-SPEC

UK-SPEC identifies the competencies and commitments required of a person of CEng status. These are grouped in five categories A-E as shown in **Table 2#**. It is PEI practice to assess competencies by means of a Presentation in categories A & B only and by means of an Interview in all of categories A to E. There is a broad mapping of the KSBs of this Standard against those competencies, also shown in Table 2#. Thus, given the intent to align PA7 with the requirements for CEng status, as far as is practicable, assessment of the Presentation and Interview at the EPA will be on the basis of the categories of KSBs as shown.

	UK-SPEC		**PA7 Standard**	
Assess't	**Competencies**	**Cat**	**KSBs**	**Ref**
Present'n & Interview	Use of a combination of general and specialist knowledge and understanding to optimise the application of existing and emerging technology.	A	Knowledge: technical	A-I
	Apply appropriate theoretical and practical methods to the analysis and solution of engineering problems.	B	Skills: analytical and problem solving	N-Q
Interview	Provide technical and commercial leadership.	C	Knowledge: general. Skills: technical and commercial leadership.	J-M R-V
	Demonstrate effective interpersonal skills.	D	Behaviours: transferrable skills.	W-Z
	Demonstrate a personal commitment to professional standards, recognising obligations to society, the profession and the environment.	E		

Table 2#