DRIVES

Development and Research on Innovative Vocational Education Skills

Rubber Technologist – Basic Level

Job Role Skill Set

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www.project-drives.eu

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INTRODUCTION

1.1 OBJECTIVE

The objective of this deliverable is to provide an introduction to described Job Role within the applied skills definition model.

1.2 PURPOSE OF THE DELIVERABLE

The purpose of this deliverable is to define skills definitions of the Rubber Technologist – Basic Level job role within the ECQA skills definition model.

1.3 SCOPE OF THE DELIVERABLE

The deliverable contains

- Description of the content of the Job Role
- Description of used Skill Sets and skills definitions, coverage of Qualification Schemas

The deliverable does not cover:

- Course development, as this will be done after the skill definitions clearly outlined the set of required courses.

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2 ECQA SKILLS DEFINITION MODEL

A skills definition contains the following items (see Fig.1):

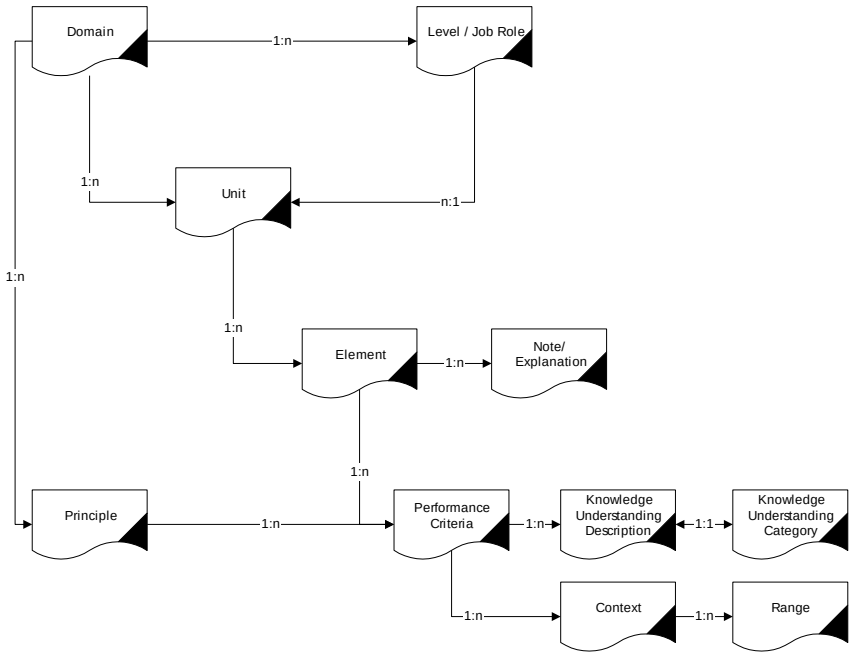


Figure 1: The Skill Definition Model (1:n = one to many relationship)

Context: A category of ranges; it represents some terminology used in a performance criterion that consists of different context, conditions or circumstances. A participant must be able to prove competence in all the different circumstances covered by the context.

Domain: An occupational category, e.g. childcare, first level management or software engineering.

Element: Description of one distinct aspect of the work performed by a worker, either a specific task that the worker has to do or a specific way of working. Each element consists of a number of performance criteria.

Evidence: Proof of competence.

Knowledge and understanding category: A category of knowledge and understanding descriptions.

Knowledge and understanding description: A description of certain knowledge and understanding. To be judged competent in a unit a participant must prove to have and to be able to apply all the knowledge and understanding attached to it.

NVQ (UK based): The National Vocational Qualification standard of England, Wales and N. Ireland.

Performance criterion: Description of the minimum level of performance a participant must demonstrate in order to be assessed as competent. A performance criterion may have relevant contexts.

Principle: A statement of good intentions; it underpins all competent domain practice.

Range: Description of a specific circumstance and condition of a performance criterion statement.

Qualification: The requirements for an individual to enter, or progress within a certain occupation.

Job Role: A certain profession that covers part of the domain knowledge. E.g. domain = Functional Safety, job role = Functional Safety Manager.

Unit: A list of certain activities that have to be carried out in the workplace. It is the top-level skill in the UK qualification standard hierarchy and each unit consists of a number of elements.

The rationales for developing the ECQA skills definition model is based on the skills definition proposed by the DTI (Department of Trade and Industry) in the UK for the NVQ (National Vocational Qualification) standards. These models have been re-used and slightly modified by other countries when they started employing skill cards [1], [2].

ECQA standards are used to describe the skills sets delivered within the DRIVES project (www.project-drives.eu). Further description and rationales are attached in annexes of this document. The ECQA structure was mapped in DRIVES project to DRIVES Reference and Recognition Framework with the links to ESCO[7], EQF[8], ECTS[9] and ECVET[10]. See more in deliverable DRIVES-D4.1.1 Reference and Recognition Framework – Analysis.pdf (www.project-drives.eu).

3 SKILLS DEFINITION FOR THE JOB ROLE "RUBBER TECHNOLOGIST - BASIC LEVEL"

3.1 THE SKILLS HIERARCHY

Using the terminology outlined in the skills definition model and including the skills identified during the demand analysis at the beginning of the project, the following skills hierarchy for the job role "Rubber Technologist – Basic Level" has been designed.

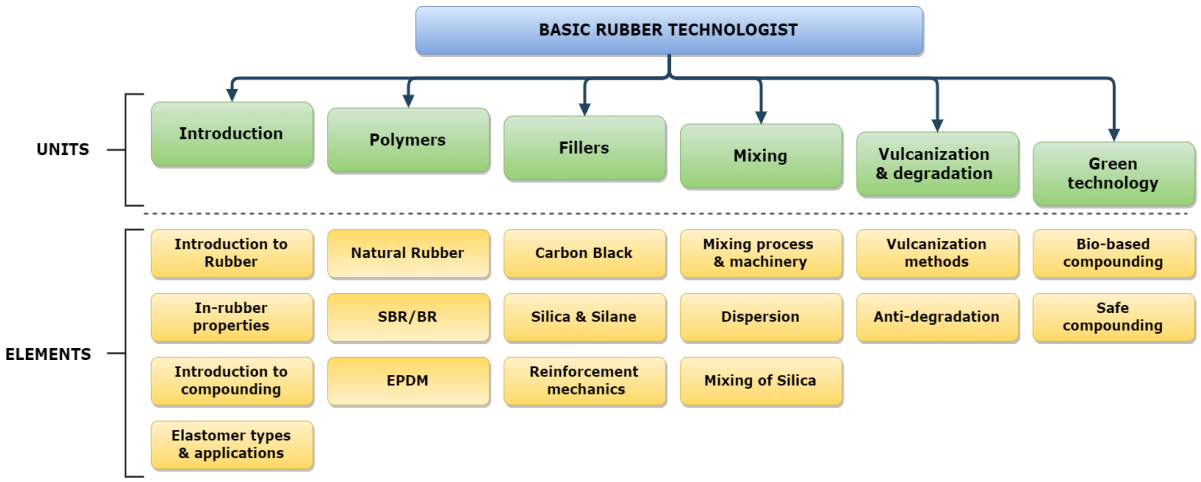


Figure 2: The Skills Set for ECQA Certified Rubber Technologist – Basic Level

3.2 THE SKILLS DESCRIPTIONS – JOB ROLE RUBBER TECHNOLOGIST – BASIC LEVEL

Domain Acronym: Engineering

Domain title: Rubber/Elastomer Technology and Engineering
Domain Description:

Rubber is known for unique elasticity and damping properties and provides irreplaceable functionality in automotive industry applications. Rubber is typically cross-linked, or vulcanized, forming a thermoset network of polymer chains and often referred to as rubber material. Road transportation vehicles are assembled using numerous rubber components with a variety of applications.

For example, rubber bushings connect chassis, engine and transmission parts to provide damping and vibration isolation; rubber sealings seal the interior of the car from moist; window wipers clear the front and back window vision; rubber tubes prevent leakage and support the transportation of fluids under the hood; etc.. All applications require different rubber compounds for their operating conditions vary, which is hidden by the similar black appearance. A main application is the rubber tire, which connects vehicles to the road and provide grip and damping, highly related to safety, comfort and driving performance. But one should be aware that, although delivering critical performance for road transport, tires contribute to environmental impact of the automotive industry. Tires account for

roughly 60% of global rubber consumption; in 2019, 2.4 billion tires are produced worldwide, a number growing 3.4% annually. The production of tires contributes to the depletion of (non-renewable) resources and the disposal causes a problematic source of waste. Often disregarded by costumers is the contribution of tires to fuel consumption of road vehicles, by energy loss mainly due to material hysteresis.

The field of Rubber Technology and Engineering aims to further improve the performance and lifecycle of rubber products, such that the depletion of resources and impact on the environment is limited, whilst customer satisfaction and safety is maximized.

Job Role Acronym: RUBTECHB

Job Role Title: ECQA Certified Rubber Technologist – Basic Level

Description:

The Skill card comprises the following thematic learning units

1. Introduction to Rubber Technology
2. Polymer Technology
3. Filler Technology
4. Mixing Technology
5. Vulcanization and Degradation mechanisms
6. Green and Sustainable technology

3.3 UNIT RUBTECHB.U1 INTRODUCTION TO RUBBER TECHNOLOGY

Acronym: RUBTECHB.U1

Title: Introduction to Rubber Technology

Description:

This unit introduces rubber material by going deeper into the general character of rubber material. The history is very relevant together with a comparison of rubber to non-rubber materials. Basic knowledge regarding in-rubber characteristics and compounding methodology gives a solid foundation for further elaborating on different rubber types and micro/macro properties of rubber compounds in following elements.

3.3.1 Unit RUBTECHB.U1 - Element 1: Introduction to Rubber Technology

Acronym: RUBTECHB.U1.E1

Element Title: Introduction to Rubber

Element Note:

In this element a general overview of rubber history is given together with an introduction in rubber material behaviour and characterization

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
RUBTECHB.U1.E1.PC1	The student has a basic understanding of history and breakthrough inventions in the rubber and tire industry
RUBTECHB.U1.E1.PC 2	The student knows the difference between thermoplastics and elastomers and is able to explain how vulcanization gives an elastic character to rubber material
RUBTECHB.U1.E1.PC 3	The student is able to explain the concepts of chain length, molecular weight distribution and their general influence on in-rubber properties and processing
RUBTECHB.U1.E1.PC4	The student is able to apply the concepts of elasticity, mooney viscosity and viscoelasticity; and has a basic understanding of associated spring/dashpot models and shear stress deformation equation
RUBTECHB.U1.E1.PC5	The student is able to draw the general stress-strain curve of rubber, separate the three different stages of strain and has a basic

Performance Criterion	Evidence Check: The student can demonstrate
	understanding of characterization of rubber tensile test properties, e.g. M100 M300
RUBTECHB.U1.E1.PC6	The student is able to assign models to sections of the stress-strain curve and recognize their behavioral phenomena. The student is able to explain the practical meaning of material related paramters of the Mooney Rivlin equation

Table 1: Performance Criteria for the Element RUBTECHB.U1.E1

3.3.2 Unit RUBTECHB.U1 - Element 2: In-rubber properties

Acronym: RUBTECHB.U1.E2

Element Title: In-rubber properties

Element Note:

Introduction in in-rubber properties and testing methods that are generally used to characterize rubber performance; with additional emphasis on tire tread properties and characterization.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
RUBTECHB.U1.E2.PC1	The student has a basic understanding of typical production and application related polymer behavioral phenoma, such as entropy elasticity and die swell
RUBTECHB.U1.E2.PC2	The student is able to name mechanical rubber properties that are statically and dynamically tested and knows their meaning, relevance for applications and sample testing methodology
RUBTECHB.U1.E2.PC3	The student has a basic understanding of sinoidal applied stress and strain response graphs that indicate a phase shift between stress and strain due to hysteresis and tangent delta quantification
RUBTECHB.U1.E2.PC4	The student knows the meaning of the glass transition temperature and the relation with tangent delta and tire tread performance
RUBTECHB.U1.E2.PC5	The student has a basic understanding of aging resistance properties under weathering and application conditions, such as ozone resistance, oil resistance and heat resistance

Table 2: Performance Criteria for the Element RUBTECHB.U1.E2

3.3.3 Unit RUBTECHB.U1 - Element 3: Introduction to compounding

Acronym: RUBTECHB.U1.E3

Element Title: Introduction to Compounding

Element Note:

Introduction in compounding terminology and common practices together with an elaboration on commonly used ingredients and their function.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
RUBTECHB.U1.E3.PC1	The student is familiar with the general steps in production of a rubber product: compounding, mixing, shaping and vulcanization
RUBTECHB.U1.E3.PC2	The student knows the concept of a compound formulation and is able to apply the conversion of PHR to mass
RUBTECHB.U1.E3.PC3	The student knows the general type of ingredients and systems that are included in the compound formulation and is able to define the ingredient's functionality
RUBTECHB.U1.E3.PC4	The student knows commonly applied fillers and general effect of fillers on in-rubber properties
RUBTECHB.U1.E3.PC5	The student knows about the main vulcanization systems (sulfur & peroxide) and the general effect of crosslink density on in-rubber properties
RUBTECHB.U1.E3.PC6	The student has a basic understanding of the purpose of mixing and dispersion, plasticizing and temperature dependence of viscosity and dispersion

Table 3: Performance Criteria for the Element RUBTECHB.U1.E3

3.3.4 Unit RUBTECHB.U1 - Element 4: Elastomer types and applications

Acronym: RUBTECHB.U1.E4

Element Title: Elastomer types and applications

Element Note:

This element gives an overview of all elastomer types and their typical in-rubber properties for which they are used in applications. The student in familiar with common applications with additional emphasis on tire technology.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
RUBTECHB.U1.E4.PC1	The student has a basic understanding of general rubber types and is able to explain the concept of main chain saturation (R/M type rubber) and its relation to external conditional in-rubber properties, such as heat, oil and ozone resistance
RUBTECHB.U1.E4.PC2	The student has a basic understanding of various rubber applications and is able to recognize conditions that are important for the choice of the polymer type
RUBTECHB.U1.E4.PC3	The student is able to choose, with help of relevant general in-rubber property tables and graphs, the appropriate elastomer type for a situation in which key performance properties are easy to recognize
RUBTECHB.U1.E4.PC4	The student knows the magic triangle of tire tread performance and is able to define the magic triangle character of silica-silane and carbon black reinforcement
RUBTECHB.U1.E4.PC5	The student knows a typical green tire tread compound and understands the changes from the past which led to this formulation
RUBTECHB.U1.E4.PC6	

Table 4: Performance Criteria for the Element RUBTECHB.U1.E4

3.4 UNIT RUBTECHB.U2 POLYMER TECHNOLOGY

Acronym: RUBTECHB.U2

Title: Polymer technology

Description: This unit goes more into detail on polymer structures and in-rubber properties. The student acquires a thorough understanding of the character of the four most commonly used polymers: NR, SBR, BR and EPDM.

3.4.1 Unit RUBTECHB.U2 - Element 1: Natural Rubber

Acronym: RUBTECHB.U2.E1

Element Title: Natural Rubber

Element Note:

This element elaborates on natural rubber and its special character compared to other polymers

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
RUBTECHB.U2.E1.PC1	The student has a basic understanding of the origin and production methods of the polymer raw material.
RUBTECHB.U2.E1.PC2	The student has a basic understanding of the polymer, grades and material components (e.g. proteins) that make for the special character of NR and related in-rubber properties
RUBTECHB.U2.E1.PC3	The student is able to explain typical NR strain crystallization phenomena and draw general NR and IR stress-strain curves.
RUBTECHB.U2.E1.PC4	The student is able to draw the moleculare structure (backbone) of NR and is able to define cis, trans and vinyl polymer chain configurations
RUBTECHB.U2.E1.PC5	The student has a basic understanding of typical NR applications and required in-rubber properties for which NR is superior to other polymer types

Table 5: Performance Criteria for the Element RUBTECHB.U2.E1

3.4.2 Unit RUBTECHB.U2 - Element 2: SBR & BR

Acronym: RUBTECHB.U2.E2

Element Title: SBR & BR

Element Note:

This element elaborates on the most commonly used synthetic polymers SBR and BR, which are related as SBR is an extended version of BR. These two polymers are commonly applied in tire treads for low rolling resistance with excellent grip.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
RUBTECHB.U2.E2.PC1	The student has a basic understanding of the production methods of the polymer raw materials.
RUBTECHB.U2.E2.PC2	The student is able to draw the polymer backbone of SBR and BR and has a basic understanding of grade, their character and acronyms.
RUBTECHB.U2.E2.PC3	The student knows typical SBR/BR applications and is able to recognize how SBR styrene and BR ratio influences in-rubber character and tire tread properties (wear, grip and rolling resistance)
RUBTECHB.U2.E2.PC4	The student knows how the SBR styrene and vinyl content influence the in-rubber character (glass transition temperature) of the polymer
RUBTECHB.U2.E2.PC5	The student has a basic understanding of difference in properties of SBR, BR and NR, especially related to tire applications

Table 6: Performance Criteria for the Element RUBTECHB.U2.E2

3.4.3 Unit RUBTECHB.U2 - Element 3: EPDM

Acronym: RUBTECHB.U2.E3

Element Title: EPDM

Element Note:

This element elaborates on EPD(M), which is an (almost fully) saturated polymer, which results in special in-rubber properties, especially when vulcanized with peroxide.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
RUBTECHB.U2.E3.PC1	The student has a basic understanding of the production method of the polymer raw material
RUBTECHB.U2.E3.PC2	The student is able to recognize the saturated polymer backbone of EPM, has a basic understanding of possible extension by third monomer for sulfur curing (EPDM) and implications of low double bond availability on processing, silane coupling and vulcanization
RUBTECHB.U2.E3.PC3	The student is able to recognize how ethylene/propylene ratio and molecular weight influence the in-rubber properties
RUBTECHB.U2.E3.PC4	The student knows beneficial properties follow from the (saturated) polymer backbone and typical applications

Table 7: Performance Criteria for the Element RUBTECHB.U2.E3

3.5 UNIT RUBTECHB.U3 FILLER TECHNOLOGY

Acronym: RUBTECHB.U3

Title: Filler Technology

Description:

This unit will go into detail on rubber reinforcement by filler technology. Fillers can be non-,semi- and highly reinforcing. For high performance applications rubber is fully filled with highly reinforcing carbon black or silica (silane). These filler are available in in various species which result in different in-rubber compound properties.

3.5.1 Unit RUBTECHB.U3 - Element 1: Carbon black

Acronym: RUBTECHB.U3.E1

Element Title: Carbon Black

Element Note:

This element will elaborate on carbon black production and reinforcement

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
RUBTECHB.U3.E1.PC1	The student has a basic understanding of the production process of thermal and furnace carbon black

Performance Criterion	Evidence Check: The student can demonstrate
RUBTECHB.U3.E1.PC 2	The student has a basic understanding of the morphology of carbon black and is able to name and explain characterizing morphological factors
RUBTECHB.U3.E1.PC 3	The student has a basic understanding of characterization methods of specific surface area and structure and knows how these influence general in-rubber properties and ease of dispersion
RUBTECHB.U3.E1.PC4	The student has a basic understanding of different characterization methods of pore and aggregate size distribution and the influence of ASD on dispersion
RUBTECHB.U3.E1.PC5	The student is able to reproduce the functionality of Carbon Black apart from the reinforcing character, such as colouring and conductivity

Table 8: Performance Criteria for the Element RUBTECHB.U3.E1

3.5.2 Unit RUBTECHB.U3 - Element 2: Silica & Silane

Acronym: RUBTECHB.U3.E2

Element Title: Silica & Silane

Element Note:

This element will elaborate on precipitated silica production and silica & silane reinforcement.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
RUBTECHB.U3.E2.PC1	The student has a basic understanding of the production process of precipitated Silica
RUBTECHB.U3.E2.PC2	The student has a basic understanding of the specific surface area grades and is able to reproduce the relation between SSA and particle diameter
RUBTECHB.U3.E2.PC3	The student is able to define the chemical nature of the silica surface

Performance Criterion	Evidence Check: The student can demonstrate
RUBTECHB.U3.E2.PC4	The student is able to recognize the difference of Silica and Carbon Black wrt filler-filler and filler-polymer interaction based on surface activity of the filler
RUBTECHB.U3.E2.PC5	The student has a basic understanding of the difference in tan delta character between silica&silane and carbon black filler
RUBTECHB.U3.E2.PC6	The student is able to reproduce mechanism and purpose of the Silica Silane Polymer reaction

Table 9: Performance Criteria for the Element RUBTECHB.U3.E2

3.5.3 Unit RUBTECHB.U3 - Element 3: Reinforcement mechanisms

Acronym: RUBTECHB.U3.E3

Element Title: Reinforcement mechanisms

Element Note:

This element will elaborate on the reinforcing phenomena of fillers on micro scale level and how they affect in-rubber properties on macro level.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
RUBTECHB.U3.E3.PC1	The student is able to associate reinforcement with more specific in-rubber properties and is able to recognize main reinforcement mechanisms in structure models
RUBTECHB.U3.E3.PC2	The student is aware of the different theoretical approaches for reinforcement with regard to adhesion and filler-filler interaction models
RUBTECHB.U3.E3.PC3	The student is able to identify the loss in shear modulus G* due to strain as being the Payne effect, is able to name one explanation of why it occurs and the effect on application level
RUBTECHB.U3.E3.PC4	The student is able to identify the Mullins effect, is able to name one explanation of why it occurs and the effect on application level
RUBTECHB.U3.E3.PC5	The student knows the effect of silane-polymer coupling on the Payne effect

Performance Criterion	Evidence Check: The student can demonstrate
RUBTECHB.U3.E3.PC6	The student is able to explain the term paradox of reinforcement and how this affects the application of e.g. hard rubber compounds

Table 10: Performance Criteria for the Element RUBTECHB.U3.E3

3.6 UNIT RUBTECHB.U4 MIXING TECHNOLOGY

Acronym: RUBTECHB.U4

Title: Mixing Technology

Description:

This unit will elaborate on mixing technology for rubber compounds. Dispersion and distribution of fillers is no sinecure and is highly relevant for high performance applications. General mixing methodology and more in-detail mixing procedures and phenomena are treated.

3.6.1 Unit RUBTECHB.U4 - Element 1: Mixing process & machinery

Acronym: RUBTECHB.U4.E1

Element Title: Mixing process and machinery

Element Note:

This element elaborates on mixing machinery and the general mixing process. Mixing is dictated by several process parameters that influence filler dispersion in the compound.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
RUBTECHB.U4.E1.PC1	The student is able to recognize different mixers and rotors, and point out their strong and weak points
RUBTECHB.U4.E1.PC 2	The student knows the concepts and relevance of mixing process parameters, such as rotor speed, temperature, torque, power and ram movement
RUBTECHB.U4.E1.PC 3	The student has a good understanding of the function of plasticizers in mixing the compound, the different grades and has a feeling for the amount that generally is used for typical applications

Performance Criterion	Evidence Check: The student can demonstrate
RUBTECHB.U4.E1.PC4	The student has a good understanding of the mixing process and is able to draft the mixing procedure of a simple compound
RUBTECHB.U4.E1.PC5	The student is able to read the mixing fingerprint and recognize faulty mixing phenomena based on the mixing fingerprint

Table 11: Performance Criteria for the Element RUBTECHB.U4.E1

3.6.2 Unit RUBTECHB.U4 - Element 2: Dispersion theory

Acronym: RUBTECHB.U4.E2

Element Title: Dispersion theory

Element Note:

Dispersion and distribution of fillers on various levels requires a solid mixing approach. This element elaborates on terminology, mixing methodology, measuring methodology and relevance of optimal dispersion.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
RUBTECHB.U4.E2.PC1	The student knows the definition of dispersion and is able to distinguish visual, macro and micro dispersion
RUBTECHB.U4.E2.PC2	The student has a basic understanding of the dispersive and distributive mixing, dispersion quality and their underlying mechanical processes (rupture, erosion, disintegration)
RUBTECHB.U4.E2.PC3	The student has a basic understanding of dispersion measurement methods
RUBTECHB.U4.E2.PC4	The student knows in general how process parameters influence dispersion mechanics and dispersion quality.
RUBTECHB.U4.E2.PC5	The student is able to explain the influence of dispersion on in-rubber properties, such as reinforcement, fatigue, tire rolling (hysteresis) and abrasion resistance
RUBTECHB.U4.E2.PC6	The student is able to explain why the Payne effect is a predictor of micro dispersion quality

Table 12: Performance Criteria for the Element RUBTECHB.U4.E2

3.6.3 Unit RUBTECHB.U4 - Element 3: Mixing of Silica & Silane compounds

Acronym: RUBTECHB.U4.E3

Element Title: Mixing of Silica & Silane compounds

Element Note:

This element elaborates on special mixing approach required for Silica&Silane compounding, which takes several steps as Silica is hard to disperse due to the polar surface and should react with silane during mixing.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
RUBTECHB.U4.E3.PC1	The student knows the general production procedure for Silica+Silane compounds, Silica/Silane coupling during mixing and Silane/Polymer coupling during vulcanization, and general mixing procedure for optimal processing
RUBTECHB.U4.E3.PC2	The student is aware of flocculation, thus degrading dispersion quality, during storage of ready-mixed compounds
RUBTECHB.U4.E3.PC3	The student has a basic understanding of Silica-Silane compound mixing and typical approaches to improve incorporation and reacivity of Silica and Silane
RUBTECHB.U4.E3.PC4	The student is able to explain the optimum dump temperature range by the Mooney viscosity vs. dump temperature graph for mixing
RUBTECHB.U4.E3.PC5	The student has a basic understanding of polymers extended with functional side groups on the backbone

Table 13: Performance Criteria for the Element RUBTECHB.U4.E3

3.7 UNIT RUBTECHB.U5 VULCANIZATION AND DEGRADATION

Acronym: RUBTECHB.U5

Title: Vulcanization and degradation

Description:

This unit will elaborate on various vulcanization systems and degradation mechanisms. A high variety of ingredients influences the degree of vulcanization and the student should be aware and able to

apply the systems to optimally develop a rubber product. High performance rubber is often prone to degradation and subsequent loss of in-rubber properties.

3.7.1 Unit RUBTECHB.U5 - Element 1: Vulcanization methods

Acronym: RUBTECHB.U5.E1

Element Title: Vulcanization methods

Element Note:

This unit will elaborate on various vulcanization systems, crosslink character and vulcanization curves.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
RUBTECHB.U5.E1.PC1	The student knows the peroxide and sulfur vulcanization system mechanisms, their difference in crosslink character and in-rubber properties
RUBTECHB.U5.E1.PC 2	The student knows "Moving Die Rheometer" method and is able to name the relevant vulcanization curve characteristics such as scorch time (ts2), vulcanization time (t90) recognize curing phenoma such as marching, plateau and reversing modulus
RUBTECHB.U5.E1.PC 3	The student is able to name typical sulfur crosslinking systems, accompanying sulfur crosslink chainlength character and resulting character of in-rubber properties, such as temperature resistance and dynamic performance
RUBTECHB.U5.E1.PC4	The student has a good understanding of various ingredients involved in the vulcanization process and their functions (activator, accelerator, crosslinker, alkalizers, stearic acid, retarder) and is able to estimate a shift in the vulcanization curve from manipulation of the compound formulation
RUBTECHB.U5.E1.PC5	The student is able to choose a suitable vulcanization system for a given situation in which requirements are easy to recognize

Table 14: Performance Criteria for the Element RUBTECHB.U5.E1

3.7.2 Unit RUBTECHB.U5 - Element 2: Anti-degradation

Acronym: RUBTECHB.U5.E2

Element Title: Anti-degradation

Element Note:

High performance rubber is often prone to degradation and subsequent loss of in-rubber properties. The degradation mechanisms are highlighted and the element elaborates on prevention of degradation.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
RUBTECHB.U5.E2.PC1	The student has a basic understanding of degradation mechanisms and the effect of degradation on functional properties
RUBTECHB.U5.E2.PC2	The student is aware of commonly applied anti-degradants and their protection mechanisms
RUBTECHB.U5.E2.PC3	The student is able to estimate degradation mechanisms based on application conditions and select the appropriate anti-degradant type(s)

Table 15: Performance Criteria for the Element RUBTECHB.U4.E2

3.8 UNIT RUBTECHB.U6 GREEN AND SUSTAINABLE TECHNOLOGY

Acronym: RUBTECHB.U6

Title: Green and sustainable technology

Description:

This unit is tailor-made to stimulate sustainable or “green” compounding among rubber technologists. Bio-based ingredients can replace traditional petroleum based ingredients and potentially toxic ingredients can sometimes be replaced by alternatives.

3.8.1 Unit RUBTECHB.U6 - Element 1: Bio-based compounding

Acronym: RUBTECHB.U6.E1

Element Title: Bio-based compounding

Element Note:

This element elaborates on bio-based polymers, fillers and oils that can replace traditional petroleum based ingredients.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
RUBTECHB.U6.E1.PC1	The student is able to explain the general difference in origin between bio-based and synthetic compounding ingredients
RUBTECHB.U6.E1.PC 2	The student is able to name high potential vegetable oils, fillers and polymers and recent advancements in the field of bio-based compounding
RUBTECHB.U6.E1.PC 3	The student is aware of the purpose and drawbacks of bio-based compounding and is able to substantiate a choice for biological instead of a synthetic ingredients
RUBTECHB.U6.E1.PC4	The student knows the challenges faced in replacing the non-polar character of petroleum based polymers, oils and fillers

Table 16: Performance Criteria for the Element RUBTECHB.U6.E1

3.8.2 Unit RUBTECHB.U6 - Element 2: Safe compounding

Acronym: RUBTECHB.U6.E2

Element Title: Safe compounding

Element Note:

This element elaborates on potentially toxic ingredients that can sometimes be replaced. The student learns to recognize and find alternatives for ingredients under suspicion of REACH.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
RUBTECHB.U6.E2.PC1	The student is aware of the potential toxicity of rubber compound ingredients and the EU REACH regulation
RUBTECHB.U6.E2.PC2	The student knows what type of ingredients and reaction products are potentially harmfull for humans and/or environment
RUBTECHB.U6.E2.PC3	The student is able to recognize potentially harmful ingredients inside rubber compounds and is able to propose alternative ingredients, or compounds, with similar functionality

Table 17: Performance Criteria for the Element RUBTECHB.U6.E2

ANNEXES

The annex provides overview of used skills set, coverage of Qualification Schemas and Legal background for Certification

ANNEX A ECQA DESCRIPTION

ECQA – EUROPEAN CERTIFICATION AND QUALIFICATION ASSOCIATION

ECQA standards are used to describe the skills sets delivered within the DRIVES project (www.project-drives.eu). ECQA is the pilot Certification body, which structure is mapped to DRIVES Reference and Recognition Framework providing the EU-wide overview of training courses and possible certifications, and micro-credentials. DRIVES Reference and Recognition Framework provides links to ESCO[7], EQF[8], ECTS[9] and ECVET[10]. See more in deliverable DRIVES-D4.1.1 Reference and Recognition Framework – Analysis.pdf (www.project-drives.eu).

Europe Wide Certification

The ECQA is the result of a number of EU supported initiatives in the last ten years where in the European Union Life Long Learning Programme different educational developments decided to follow a joint process for the certification of persons in the industry.
Through the ECQA it becomes possible that you attend courses for a specific profession in e.g. Spain and perform a Europe wide agreed test at the end of the course.

Access to a Vast Pool of Knowledge

ECQA currently supports 27 professions in Europe and with the continuous support until 2012 by the European Commission the pool is growing to 30 certified professions in Europe. ECQA offers certification for professions like IT Security Manager, Innovation Manager, EU project manager, E-security Manager, E-Business Manager, E-Strategy Manager, SW Architect, SW Project Manager, IT Consultant for COTS selection, Internal Financial Control Assessor (COSO/COBIT based), Interpersonal Skills, Scope Manager (Estimation Processes), Configuration Manager, Safety Manager, and so forth.

The ECQA guide can be downloaded at www.ecqa.org -> Guidelines.

Defined procedures are applied for:

- Self assessment and learning
- http://www.ecqa.org/fileadmin/documents/Self_Assessment/eucert-users-self-assessment-learning-guide-v5-doc.pdf
- Exam performance
- http://www.ecqa.org/fileadmin/documents/ECQA_Exam_Guide_Participant_v2.pdf

ECQA SKILLS DEFINITION MODEL

The ECQA skills definition model, used for Job Role definition, is described in section 2 of this document.

ECQA SKILL SET STRATEGY

Imagine that in the future Europeans will have a skill set like a card with a chip which stores your skill profile to fulfil specific professions, job roles, and tasks. It's working like an ID card. This future scenario requires -

- A standard way to describe a skill set for a profession, job, or specific task.
- A standard procedure to assess the skill and to calculate and display skill profiles.

Such a common set of skill sets in Europe is needed due to the free mobility of workers. European countries such as UK, The Netherlands, and France already have well established open universities which support APL (Accreditation of Prior Learning). In APL the skills of students are assessed, already gained skills are recognised, and only for the skill gaps a learning plan is established. The skill assessment bases on defined skill units and a skill profile displaying how much of the skill units are covered.

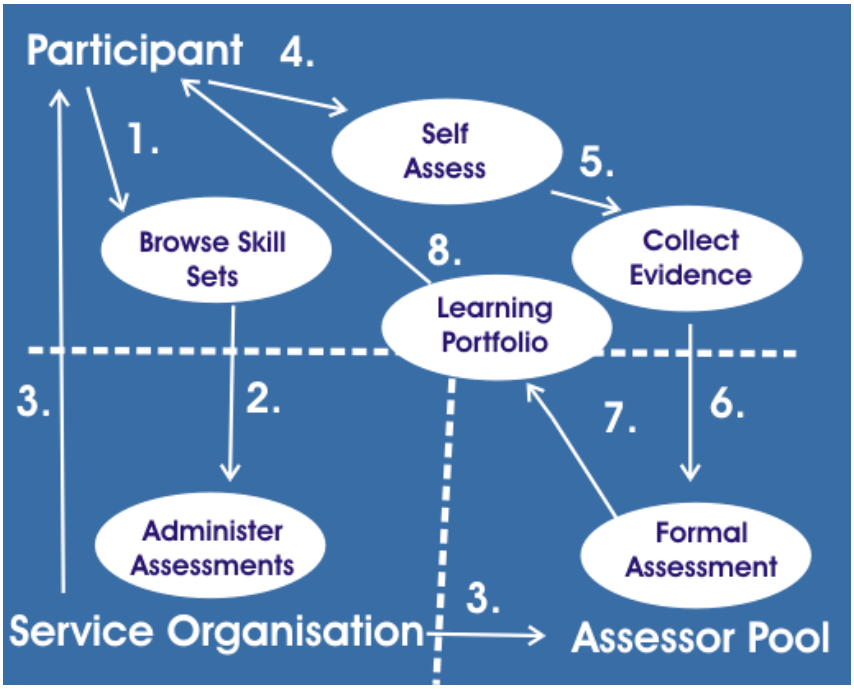
In a previous project CREDIT (Accreditation of Skills via the Internet) [1] in which some of the project partners were involved such an Internet based skills assessment system has been built. Therefore another possible scenario of the future is that representative educational bodies per country in Europe maintain skill profiles in databases which can be accessed via defined ID codes for people.

ECQA SKILLS ASSESSMENT MODEL

Step 1 – Browse a Skills Set: You select a set of skills or competencies, which are required by your profession or job using national standards or your company standards. You browse different skills cards and select a job role you would like to achieve.

Step 2 – Register for Self Assessment with a Service Unit : This can be a service unit inside your own company (e.g. a personnel development department) or a skills card and assessment provider outside your company which offers skills assessment services. In case of the Safety Manager Project the registration will automatically assign a predefined service unit.

Step 3 – Receive an Account for Self-Assessment and Evidence Collection : With the registration you automatically received an account to login to the working space in which you can go through the steps of online self assessment and the collection of evidences to prove that you are capable of certain performance criteria.



Picture 1: Basic steps of the skills assessment model

Step 4 – Perform Self Assessment: You log into the system , browse through the skills required and self assess performance criteria, whole elements or whole units with a standard evaluation scale of non-applicable, not adequate, partially adequate, largely adequate, and fully adequate. A skills gaps profile can be generated and printed illustrating in which areas your self assessment shows improvement potentials.

Testing of Skills (Addition to Step 4) – The system provides a multiple-choice test for each performance criteria so that you can check your capabilities as realistically as possible.

Step 5 – Collect Evidences: Before you want to enter any formal assessment you need to prove your skills by evidences. Evidences can be any electronic files (sample documents, sample graphics, results of some analysis, etc.) or any references with details (e.g. a certificate received from a certain institution). Evidences you can then link to specific performance criteria or whole elements of skills units.

Testing of Skills (Addition to Step 5) – In traditional learning schemes people have always needed to go to a learning institution (university, accreditation body, professional body, etc.) to take exams and they received a certificate if they pass. This traditional approach however is insufficient when it comes to measuring experience and (soft) skills learned on the job and fails to give recognition to skills gathered on the job. The APL (Accreditation of Prior Learning) approach, by contrast, collects so called evidences. Evidences can be certificates obtained in the traditional way, but also references from previous employers, materials from previous projects in which the person took ownership of results (e.g. a test plan) to prove their capability, as well as any kind of proof of competence gathered on the job. The assessors will then evaluate the evidences provided and not only rely on certificates and exams.

Step 6 – Receive Formal Assessment: Formal assessors are assigned by the service unit to the skills assessment. Once formal assessors log into the system they automatically see all assigned assessments. They select the corresponding one and can see the uploaded evidences. They then formally assess the evidences and assess the formal fulfilment of performance criteria, whole elements or whole units with a standard evaluation scale of non-applicable, not adequate, partially adequate, largely adequate, and fully adequate. In case of missing competencies they enter improvement recommendations, a well as learning options.

Step 7 – Receive Advise on Learning / Improvement Options: After the formal assessment the participants log into the system and can see the formal assessment results from the assessors, can print skills gaps profiles based on the assessor results, and can receive and print the improvement recommendations and learning options. If required, the generation of learning options can also be automated through the system (independent from assessor advises).

ECQA CERTIFICATE TYPES

In the standard test and examination procedures for levels of certificates are offered:

- Course Attendance Certificate
  - Received after course attendance
  - Modular per Element

- Course / Test Certificate
  - Test in a test system (European pool of test questions)
  - 67% satisfaction per element
- Summary Certificate
  - Overview of covered elements where the student passed the test, all elements shall be covered
  - Generation of certificate
- Professional Certificate
  - Uploading applied experiences for review by assessors
  - Rating by assessors
  - Observation of 2 years

The certificates show credited elements in comparison to all required.

ANNEX B ECQA COVERAGE OF QUALIFICATION SCHEMAS

MAPPING BASED ON NVQ QUALIFICATION LEVELS

Qualification / training levels: Five levels of qualification / training are defined by European legislation and this structure can be used for comparability of vocational qualifications from the different European countries.

- Level 1: semi-skilled assistant performing simple work
- Level 2: basic employee performing complex routines and standard procedures
- Level 3: skilled professional with responsibility for others and performing independent implementation of procedures
- Level 4: middle management & specialist performing tactical an strategic thinking
- Level 5: professional / university level

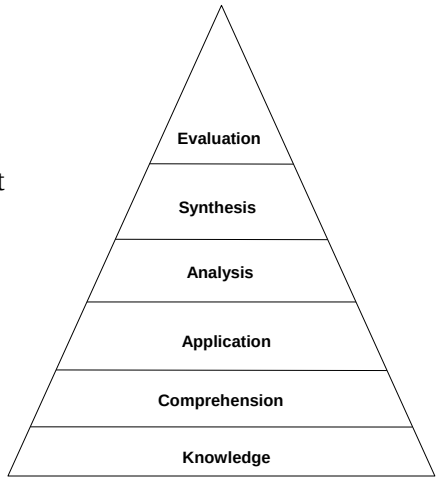
In most cases the same job role can be offered on different levels. e.g. IT Security Manager Basic Level (NVQ level 2), IT Security Manager Advanced level (NVQ Level 3), and IT Security Manager Expert Level (NVQ Levels 4 and 5).

MAPPING BASED ON EUROPEAN QUALIFICATION FRAMEWORK (EQF) LEARNING LEVELS

- Six level taxonomy:

  Level 0: I never heard of it

  1. Knowledge (I can define it):
  2. Comprehension (I can explain how it works)
  3. Application (I have limited experience using it in simple situations)
  4. Analysis (I have extensive experience using it in complex situations)
  5. Synthesis (I can adapt it to other uses)
  6. Evaluation (I am recognized as an expert by my peers)



Picture 3: Blooms Learning levels

Level	Knowledge	Example
Level 1	Basic general knowledge	
Level 2	Basic factual knowledge of a field of work or study	
Level 3	Knowledge of facts, principles, processes and general concepts, in a field of work or study	Six Sigma Yellow Belt
Level 4	Factual and theoretical knowledge in broad contexts within a field of work or study	
Level 5	Comprehensive, specialised, factual and theoretical knowledge within a field of work or study and an awareness of the boundaries of that knowledge	
Level 6	Advanced knowledge of a field of work or study, involving a critical understanding of theories and principles	Six Sigma Green Belt
Level 7	• Highly specialised knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking and/or research • Critical awareness of knowledge issues in a field and at the interface between different fields	Six Sigma Black Belt

Level	Knowledge	Example
Level 8	Knowledge at the most advanced frontier of a field of work or study and at the interface between fields	Six Sigma Master Black Belt

Picture 4 : EQF Learning levels

MAPPING BASED ON ECTS AND ECVET SCHEMA

ECQA has established a procedure to map ECQA skills sets onto the ECTS (European Credit Transfer System) and the ECVET framework n the European Union.

A job role is assigned ECTS and ECVET points using a defined framework.

ECTS Mapping

Each element of the skills set is assigned hours of lecturing and exercises. These hours determine the ECTS points which are then agreed among a cluster on different universities in Europe.

Level	Knowledge	AQUA	ECTS	Safety Manager	ECTS
Level 1	Basic general knowledge	-		-	
Level 2	Basic factual knowledge of a field of work or study	-		-	
Level 3	Knowledge of facts, principles, processes and general concepts, in a field of work or study				
Level 4	Factual and theoretical knowledge in broad contexts within a field of work or study				
Level 5	Comprehensive, specialized, factual and theoretical knowledge within a field of work or study and an awareness of the boundaries of that knowledge				
Level 6	Advanced knowledge of a field of work or study, involving a critical understanding of theories and principles	AQUA - Automotive Quality Integrated Skills - presentations / theory	3	AQUA - Automotive Quality Integrated Skills - presentations / theory	3
Level 7	- Highly specialized knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking and/or research - Critical awareness of knowledge issues in a field and at the interface between different fields	AQUA - Automotive Quality Integrated Skills - with exercises to apply on nan example (e.g. ESCL)	4	AQUA - Automotive Quality Integrated Skills - with exercises to apply on nan example (e.g. ESCL)	4
Level 8	Knowledge at the most advanced frontier of a field of work or study and at the interface between fields	AQUA - Automotive Quality Integrated Skills - implementation in a research at PhD level / with link to a real project	5	AQUA - Automotive Quality Integrated Skills - implementation in a research at PhD level / with link to a real project	5

Picture 5 : Example Automotive Quality Engineer and Safety Manager

The 2 job roles illustrated in the picture above have been assigned to ECTS and are taught using the same skills set at industry and also universities.

ECVET Mapping

Also ECQA provides a framework to assign ECVET points onto elements of the skills set. The ECQA guidance recommends to offer the ECQA course (which is offered as a lecture at university) as a short course (2 weeks with exercises) in industry to retrain for a job role in industry. The recommended size is 30 ECVET points in total. The lecturing time and exercise per element determine how many ECVET points ae assigned to an element of the skills set.

Automotive Quality Engineer			
			ECVET L7&8
U1	4	U1.E1: Introduction	2
		U1.E2: Organisational Readiness	2
U2	32	U2.E1 Life Cycle	8
		U2.E2 Requirements	8
		U2.E3 Design	8
		U2.E4 Test and Integration	8
U3	12	U3.E1: Capability	2
		U3.E2: Hazard and Risk Management	8
		U3.E3 Assessment and Audit	2
U4	12	U4.E1: Measurement	6
		U4.E2: Reliability	6
		ECVET Points Total	60

Picture 6 : ECVET Mapping example - Automotive Quality Engineer

Functional Safety Manager / Engineer			
			ECVET L7&8
U1	2	U1.E1 International Standards	1
		U1.E2 Product Life Cycle	1
		U1.E3 Terminology	
U2	4	Safety management on organisational	1
		Safety Case Definition	1
		Overview of Required Engineering an	1
		Establish and Maintain Safety Plannin	1
U3	16	System Hazard Analysis and Safety Co	4
		Integrating Safety in System Design &	4
		Integrating Safety in Hardware Design	4
		Integrating Safety in Software Design	4
U4	4	Integration of Reliability in Design to I	2
		Safety in the Production,Operation an	2
U5	4	Legal aspects and Liabilities	2
		Regulatory & Qualification Requireme	2
		ECVET Points Total	30

Picture 7 : ECVET Mapping example – Functional Safety Manager / Engineer

ANNEX C ECQA LEGAL BACKGROUND FOR CERTIFICATION

ISO/IEC 17024 STANDARD FOR PERSONNEL CERTIFICATION PROGRAMMES

The ISO/IEC 17024 standard describes standard processes for the examination and certification of people. Some of the basic principles described include:

- Standard exam procedure
- Standard certification procedure
- Identification of persons receiving the certificate
- Independence of examiner and trainer
- Certification system that allows to log the exam to keep a record/proof that the examinee passed the exam
- Mapping of processes towards ISO 17024

ECQA AND ISO/IEC 17024 STANDARD

- ECQA defined standard exam processes
- ECQA defined standard certification processes
- ECQA developed an exam system that generates random exams and corrects exams.
- ECQA developed a certification database to identify persons and map them to exam results
- ECQA established a mapping onto the ISO 17024 norm and published that in form of a self declaration.

LIASION WITH NATIONAL UNIVERSITIES

ECQA established cooperation with national universities who teach job roles with ECTS. The same job roles are offered with ECVET on the market by training bodies.

ANNEX D REFERENCES

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