OULUN AMMATTIKORKEAKOULU

Jere Liuska

PRODUCT AUDIT IN ENSTRUCTOR APPLICATION

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Jere Liuska
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ABSTRACT

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Author: Jere Liuska
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The thesis was commissioned by PKC Group Ltd. The purpose of this thesis was to create a digital version of the product audit for the Enstructor application. This would also standardize product audit. The differences between the digital and paper audit method were compared during the thesis and future developments for the Enstructor were also examined. The history of quality and different quality standards was also covered in this thesis.

As a result of this thesis the product audit in Enstructor application is now in use at PKC Group's factories in Europe and South America.

Keywords: Quality, Enstructor, Audit, Standards

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VOCABULARY

PDF = Portable Document Format

MTSL = Motherson Technology Services Limited

ISO = International Organization for Standardization

IATF = International Automotive Task Force

TS = Technical Specification

OHSAS = Occupational Health and Safety Assessment Series

VDA = Verband der Automobilindustrie

1 INTRODUCTION

PKC Group is a leading international company which designs and manufactures wiring harnesses mainly for the commercial vehicle industry. PKC Group is a part of the Motherson Group. PKC Group has factories in Brazil, China, Germany, Lithuania, Poland, Serbia, United Kingdom, United States and Mexico. PKC Group's wide expertise and innovative solutions have helped the company to grow to play a central role when reliable, durable, and effective wiring harnesses are needed in commercial vehicles. PKC Group employs over 30,000 people. (1.)

The current internal product audit process in PKC Group is done by pen and with printed Microsoft Excel sheets. This is time-consuming as you need to print the documents first and then scan back to the computer to make them easier to find. The quality team wanted a better solution for the internal audit process. They also wanted to standardize the product audit. That is why Enstructor was designed. Enstructor is a web-based tool that allows you to create large and even complex diagrams easily. Diagrams can be run in a user-friendly format, for example on a tablet or phone and all the information is saved to server. This will be better for nature because no excessive paper will be wasted as Enstructor is paperless solution. (2.)

The objective of this thesis is to optimize the Enstructor in such a way so it would meet align seamlessly with the specific requirements presented by the quality and other dedicated teams within the PKC Group. This requires dual-fold approach:

1. Improving the Enstructor: customization/design of the Enstructor platform to ensure it meets the unique functional needs of teams. The goal is to provide them with a ready-to-use tool that increases efficiency and matches their workflow.
2. Comparing the auditing methods: Comparison of the digital and paper-based audit methods, focusing on different parameters such as productivity to user and user-friendliness.

2 QUALITY

There is not one clear description for what quality means. Quality can be seen from different perspectives, and it may mean something different for different people. Quality is often referred to as "be something good" from that person's perspective who is using the service or product. (3, p. 35.)

Even before the emergence of organized society, during the barter economy, the buyer and manufacturer were in direct contact with each other. The quality of the product played a very important role, and it was often compared to the same kind of items before buying. Quality had a direct impact on the final price of the product. It can therefore be said that quality has had an impact on business for a long time. (4, p. 15).

Quality could be referred to as conformity. For example, two different consumers are buying a car, one wants a car that moves forward and has the basic features, while the other wants a car with, say, cruise control and leather seats in addition to the basic features. Although the products are completely different, both meet the customer's requirements in the way they want. You could say that quality is what the customer wants. Quality is the fulfilment of a client's requirements, expectations, habits, and needs. (3, pp. 36-37.)

As a result of the industrial revolution, products were manufactured in long series by machine. This also affected the size of production plants and the labor requirements. A large increase in the workforce was necessary, which also meant that most of the workers were not trained. Errors were almost guaranteed. (4, p. 16).

A professional team of quality inspectors was set up to find defects in products. Their task was to ensure the quality of the work and the materials used, thereby fulfilling customer specifications. They would report the anomaly and give suggestions on how to fix the process. Big factories even had their own departments for quality inspectors, which could include more than 100 inspectors. (4, p. 16.) The main reason to improve quality is to achieve better customer satisfaction. (3, p. 15).

2.1 PDCA cycle

Physicist Walter Andrew Shewhart developed one of the first tools for quality control, called the Shewhart circle. He had a student called William Edwards Deming who reformulated his teacher's theory. This is why today we often refer to the Deming circle. Most people know this model as PDCA (Figure 1.), which stands for plan, do, check and, act. The PDCA can be opened, as done below (6.):

1. Plan: Identify the objectives of the process and plan the necessary changes to achieve them,
2. Do: Put the changes into action,
3. Check: See how well the results met expectations from a performance perspective,
4. Act: Make the change permanent by standardization or start over if it does not work.

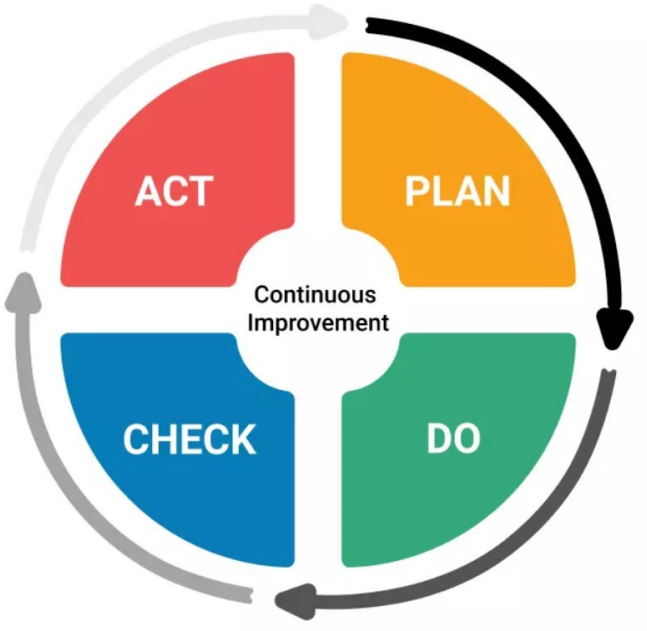


FIGURE 1. PDCA model (6.)

2.2 Standards

Standard is a word with multiple different meanings. It can be used as an example when speaking about eating somewhere and some place does not fulfill your standards. Or maybe some companies have quality standards which they want to provide for customers. The word comes up in many different uses. (7.)

We maybe do not even realize, but we use standards in our daily life. Example when using paper, we have couple of different sizes from where to choose, but the sizes are same for all people, because they were configured in standard. (7.)

When we talk about standard in terms of quality, standards provide framework which includes features, recommendations, criteria, or descriptions that can be used to make sure that utilities, procedures, items, and resources are fit for specific purpose. To achieve customer's quality requirements, companies and organizations often turn to standards for methods, definitions and instructions that help them achieve this objective. Figure 2 shows the principles of quality standards. (8.)

FIGURE 2. Principles of Quality Standards (8.)

From a customer's perspective standards provide a kind of safeguard, knowing that products were produced in the same way, following the same manufacturing methods and practices followed up with quality inspection which is defined by standards. (8.)

2.2.1 Standards used in PKC Group

The automotive industry's stringent quality requirements, as well as the Group's internal desire to improve, have guided the development of quality management systems over the years. This has also been reflected in the results, as over the years, PKC Group has received several quality awards from various customers in recognition of its superior quality. (9.)

Each customer has its own quality standards, on which PKC Group's internal standards are based. Customers usually have general requirements that apply to each product, but individual products may also have their own requirements.

PKC Group requires each of its production facilities to have an IATF 16949 quality management system certified by a third party. As IATF 16949 contains only automotive specific additional requirements, production facilities are required to comply with ISO 9001:2015. Relevant VDA standards must also be followed. In addition, the environmental management system must meet the standards set by ISO 14001. If required by the customer base or business environment, OHSAS 18001 certification should be considered. (9.)

2.3 Quality management system

A quality management system could be described as a system for monitoring to ensure that the customer is satisfied with the final product. When used, the system generates information that enables the people concerned to react and make decisions if something requires a response. In addition to operational processes, a proper system also includes processes that describe how to make the system better. An effective quality management system can be illustrated by the Figure below. (4, p. 50.)

FIGURE 3. Effective quality management system illustrated (4, p. 50.)

IATF 16949 standard can be used as base model for quality management system. Standard highlights the importance of customer focus, adopting a process-oriented approach, and the need for continual improvement. It serves as a basis for organizations to reliably deliver products and services that meet customer specifications, while adhering to relevant legal requirements. Standard can be easily illustrated in the form of PDCA model as seen in Figure 4. (5.)

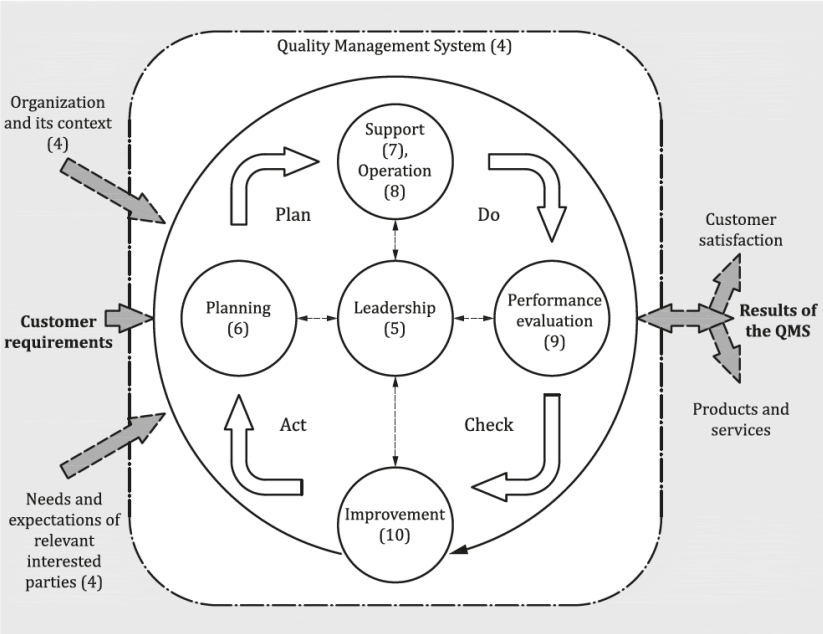


FIGURE 4. IATF 16949 presented in PDCA cycle (5.)

2.4 Internal audit

IATF 16949 defines an audit as a systematic, independent, and documented process for obtaining and objectively evaluating audit evidence to determine the extent to which agreed criteria are met. Internal audits are first-party audits and are performed by trained PKC employees. Internal audits are a systematic process to obtain evidence of compliance with certain requirements. (5.) These requirements are PKC's internal requirements based on the IATF and VDA standards. Internal audits can be divided into three types:

- Quality management system audit,
- Process audit,
- Product audit.

The focus of this thesis is on the product audit, as the thesis concerned the conversion of the product audit into a flow for use in Enstructor. (9.)

2.4.1 Product audit

To be sure that product meets the conformity to all specific requirements such as labelling, functionality, packaging, and product dimensions, quality system requires a company to carry out audits on a product at appropriate stages and at specified intervals of production and delivery. (10, p. 575.)

Product audit in PKC Group is based on German Association of the Automotive Industry's (VDA) published VDA 6.5 standard which is a guideline for companies to manage their product audit programs. VDA 6.5 is based on ISO 19011 standard, but it has addons which are meant for automobile industry. VDA 6.5 is part of the larger VDA 6 quality management system. (11.)
Every different plant had their own modified version of product audit which means it was not standardized before. Standardization is good as you can use the same base of product audit for every plant. This also helps when the process audit data is analyzed, errors or improvements are easier to detect. (9.)

3 COMPARISON OF PAPER-BASED AND ELECTRONIC AUDITING

If we think Enstructor as a digital audit method and how it compares to a paper-based auditing method, it was clear that the paper-based method was not so accurate as the digital version. This is because it is easier to lead the user down a different path (in Enstructor) with additional questions if the user answers the question in a certain way. In a paper-based method this would not be so easy.

Another advantage of the digital version is that it can even monitor the results of a single step or question, as well as the outcome of the entire product audit outcome using various automated methods. For example, the digital method facilitates standardization, which makes it easier to analyze results comprehensively, even between different factories during product audit. The digital method also allows for a quick update of the product audit. For example, only one process can be updated, and this same process can be copied to each different factory in just a few minutes. (9.)

From the user's point of view, getting used to a new system is always difficult at first, as we have seen during this project. Even if the interface is simple, but if the contrast is between a paper-based method using a pen as a tool and a tablet, for example, for some users the paper version would certainly be the first choice. Enstructor also requires the internet connection to work, while the paper version does not. This means that, for example, during a power outage, an audit may not be possible. This is why it is always a good idea to have a paper version on hand. (9.)

4 ENSTRUCTOR

Enstructor is a web-based program in which users can easily make even complicated flow charts. When considering the advantages of the digital auditing method through the lens of Enstructor, its ease in guiding auditors step-by-step stands out. For example, adding pictures and videos to steps makes it easier to explain. This feature is particularly useful for training users (13.)

Charts are known as processes in Enstructor. Every process contains steps. A single step can contain text, pictures, videos, PDF file, user-fillable sheet, or decision. Step count is not limited by Enstructor. Processes can be displayed and seen from the Enstructor's side for viewer. (13.)

Enstructor is built by requirements given from PKC Group. These requirements are based on customer and vehicle industry standards. It has been developed mainly to be used in internal product audits, but it has also been used in environment, health & safety organization and in normal production. Enstructor has been built with co-operation with Motherson's subsidiary MTSL. (13.)

Enstructor improves user understanding by offering straightforward benefits. A key example is the ease of translating the software into the user's preferred language. It is possible to maintain a base process in English and update additional elements in the chosen language, allowing for complete program translation. (13.)

Furthermore, Enstructor effectively prevents cheating. Every action taken by a user is recorded in the specific process data. It may include mandatory steps that must be completed for progression, ensuring compliance and accuracy. (13.)

The Enstructor also features a built-in grading model, which evaluates process results based on pre-established guidelines. (13.)

Overall, Enstructor benefits quality teams significantly by reducing the manual workload - there is no longer a need to print out paperwork and update it on servers. However, it does have its drawbacks, such as the fact that it requires a device like a phone, tablet or computer and a reliable internet connection, without which Enstructor cannot be used (13.)

4.1 Enstructor 6.0

Enstructor was previously in version number 5.0. Quality team wanted a couple of changes for the program so it would be better suitable for their needs and requirements. There was a total of 15 different changes which were included in the offer for the new update. In the next chapters we go through the main changes they wanted, how these were designed and what was the result.

4.2 Updates requested

As mentioned before the list of updates wanted was quite long. There was a total of 15 different updates, but in the following list goes through the main points of the desired updates:

1. Automatic result for a process, which can be specified on a process-by-process basis.
2. Menu for viewer side and the ability to see the previous results of the process the user is running.
3. New check sheet type, where the user has the possibility to add new rows.
4. Check Sheet update: automatic result depending what User answers.
5. New Activity type: Mandatory Picture or Comment.

4.3 Planning updates

Each update was designed to serve as many users as possible, in other words, it was not over-specified to do thing X. Next section goes through the changes planned for Enstructor. It also opens more about their implementation/functionality.

4.3.1 Automatic grading function

An automatic process result was the first and most important feature that the quality team wanted, as this feature would remove the responsibility for a wrong answer from the user's shoulders. The idea for automatic result was to calculate the score fields from check-sheets. The first step was to calculate all the checkpoints, which were introduced and implemented to Enstructor in 2022. The idea was simple, as shown in Figure 5. Total count of all columns in the score fields and percentage of points answered. This was crucial thing so we could have some kind of calculation before automatic grading could have been implemented.

FIGURE 5. Design of calculation of checkpoints

As the score points were dynamic, the orientation needed to be changed. This was no issue and the final design (Figure 6.) was easier to understand.

Score Field	Count	Percentage
OK	54	96.43%
NOK	0	0.00%
Not applicable?	0	0.00%
YES	1	1.79%
NO	0	0.00%
Major	0	0.00%
Minor	1	1.79%
Not Responded	0	0%
Total	56	

FIGURE 6. Final calculation of checkpoints

When the calculation of all the checkpoints was ready, it was easy to design an automatic result function (Figure 7). The idea was to create a kind of “if statement” that would have a column name as an expression, a comparison operator, a percentage of the answer, and a logical operator to link two expressions (columns) together. Column names would be searched automatically by the process itself. For example, if the user answers "OK" and answers equal to 50%, the result of the process would be "Passed." This would be presented in the list in the following way:

- Column name 1: OK
- Comparison Operator 1: ==
- Percentage 1: 50
- QC Process Status: Passed

The sequence of the list is also important, as the first point is checked first, and if it is true, no other statements are checked. If it is not true, the second statement is checked, and the list would continue until the statement was true.

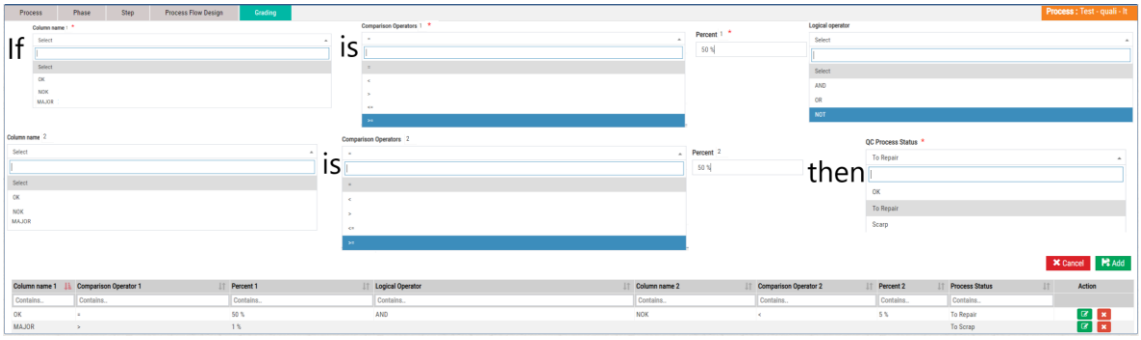


FIGURE 7. Grading window design

For comparison operators (Table 1), the design was simple as they are used in every code language. Comparison operators are used to compare the percentages of answered columns to the user-specified value.

Operators	Meaning
==	Equal
!=	Not equal
>	Greater than
<	Less than
>=	Greater than or equal to
<=	Less than or equal to

TABLE 1. Comparison operators and meanings

For logical operators, the idea was to have three of them. In Table 2, all logical operators are listed, and their meanings given. Logical operators are used to link two column statements together.

Operators	Meaning
AND	True if both column name operands are true
OR	True if either of the operands is true

NOT	True if operand is false

TABLE 2. Logical operator

The final product for automatic grading is presented in Figure 8. There was one modification from the original idea, which was linking the grading to the station. This was a good idea, as some of the clients could have different requirements, and this allows for greater flexibility. Other than that, the final product was just as designed.

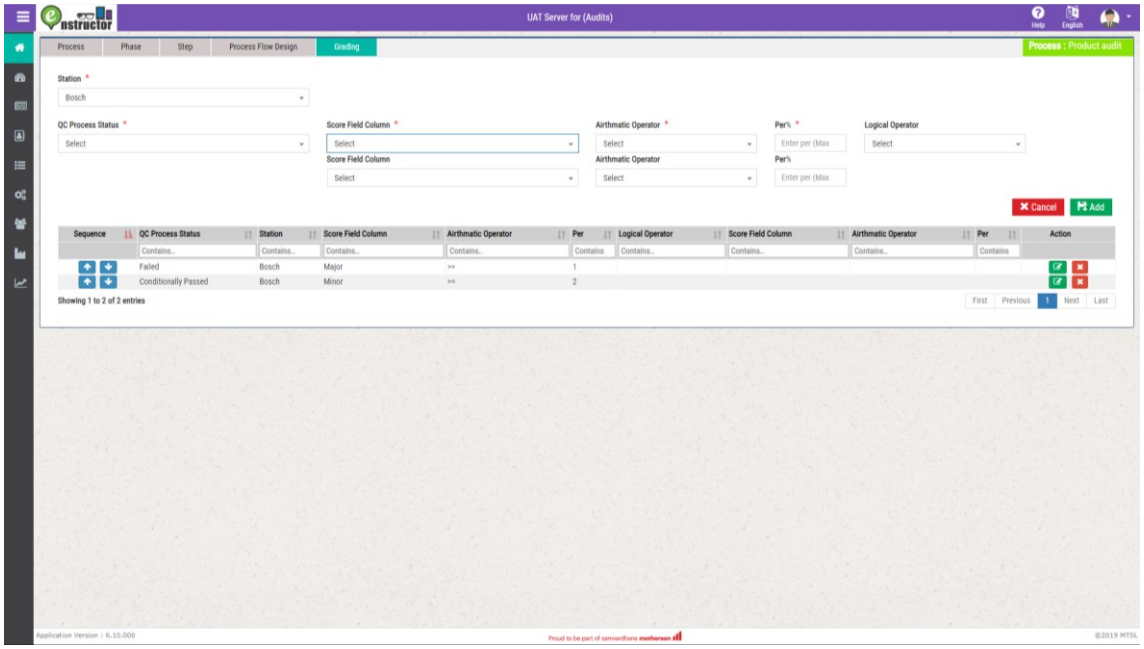


FIGURE 8. Grading window final product

For the viewer, the result of the process is shown, as shown in Figure 9. The user can only click and assign the result, which is coming from the automatic grading function, if this is enabled for the

process. If this function is not enabled, the user could choose from all the assigned results, whatever result they wanted.

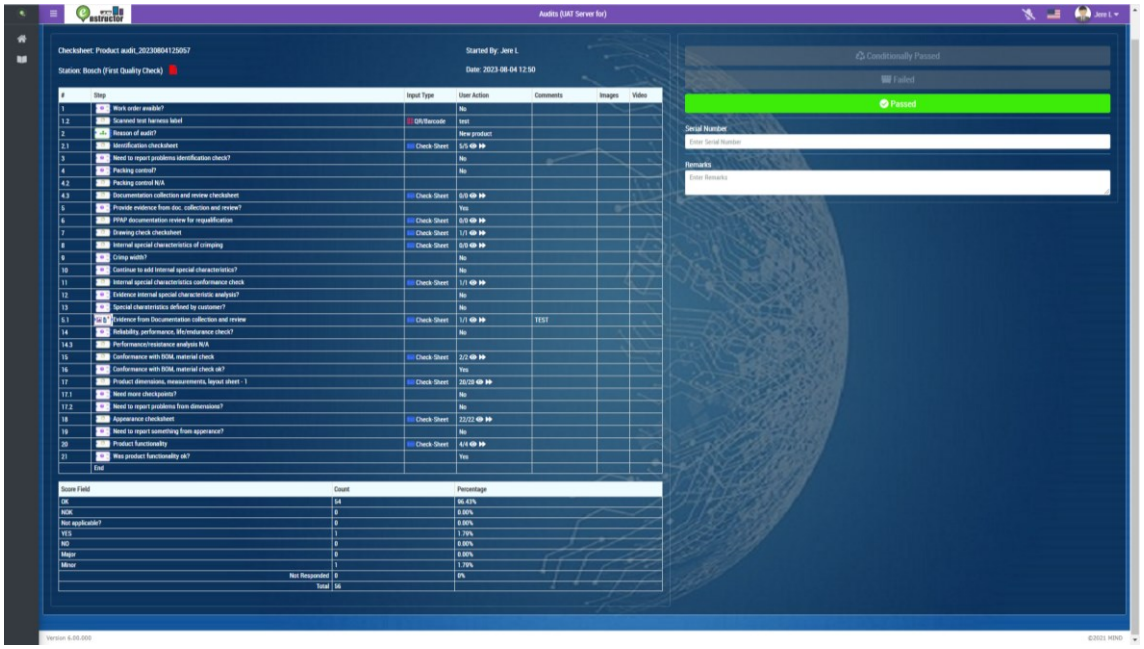


FIGURE 9. End view for user with automatic grading enabled

4.3.2 Check-sheet modification that allows user to add rows

Checking the dimensions of harnesses is done using checklists with a numerical indicator of the checkpoint. One checklist contains about 20 lines, and if the user needs more points, each checklist is followed by a question asking if the user wants more points. In some cases, the user will fill in only three or five lines. The remaining 15 lines must be manually marked as 'not applicable'. This takes a lot of time. This is why the "Add a row" function was designed. It would automatically calculate the number of the next line and add it to the checklist. This would allow only one line to be

added to the checklist, and the user could create more if necessary. Figure 10. shows the design structure of the function.

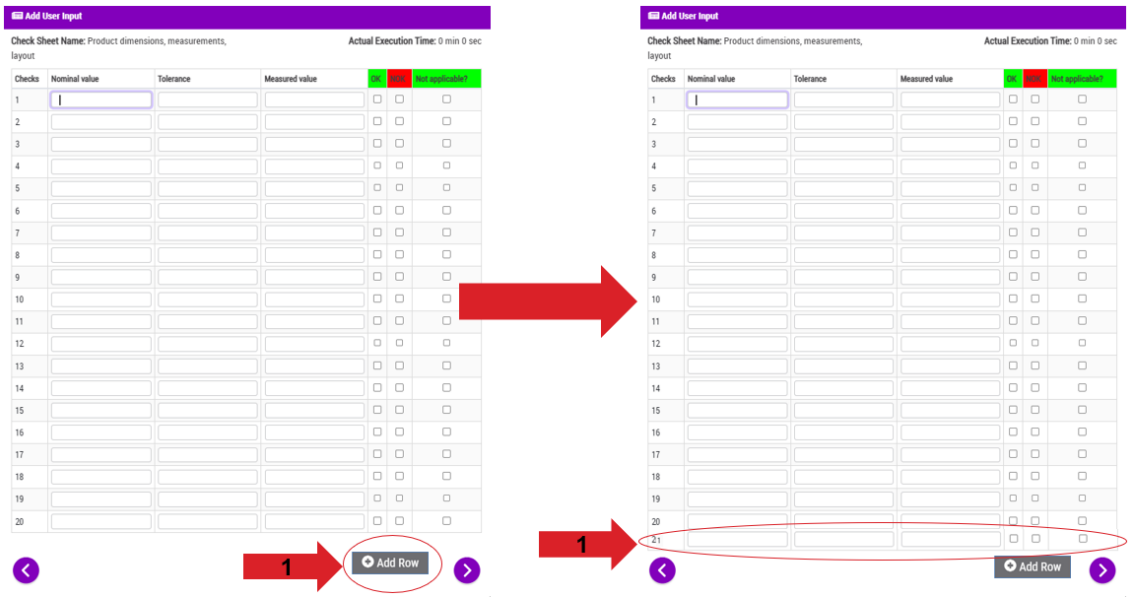


FIGURE 10. Add row functionality

This means if the user clicks “Add Row” button, a new row with new number (which is in the first column) would be added to the check-sheet. In Figure 11, is shown the “Add Row” functionality in use. To have this special function to add numbers after each row to be function, designer needs to tick “Is sequence” from Template master. Otherwise, numbers will not come automatically, and only empty rows will appear. This has been done so that the "Add Row" function can be used in every checklist.

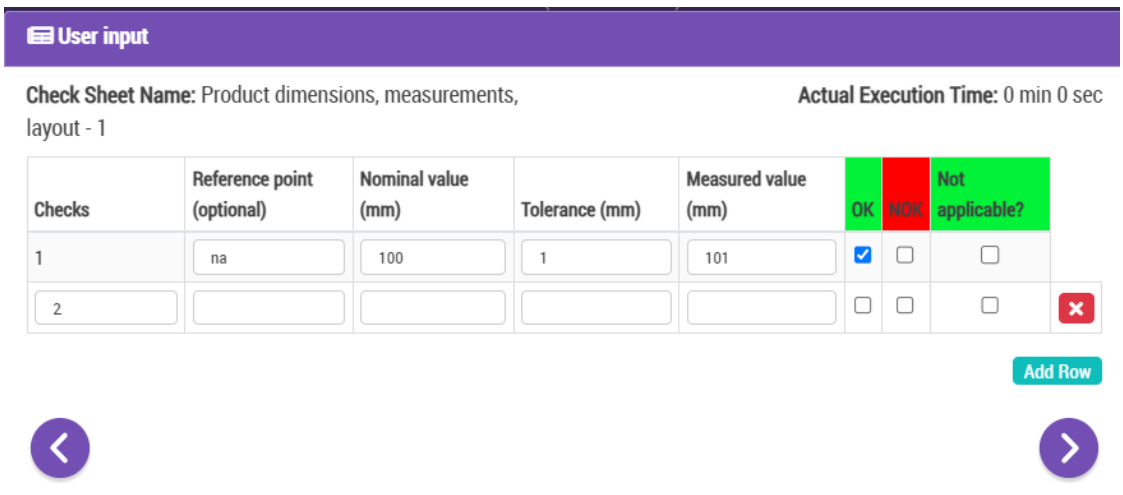
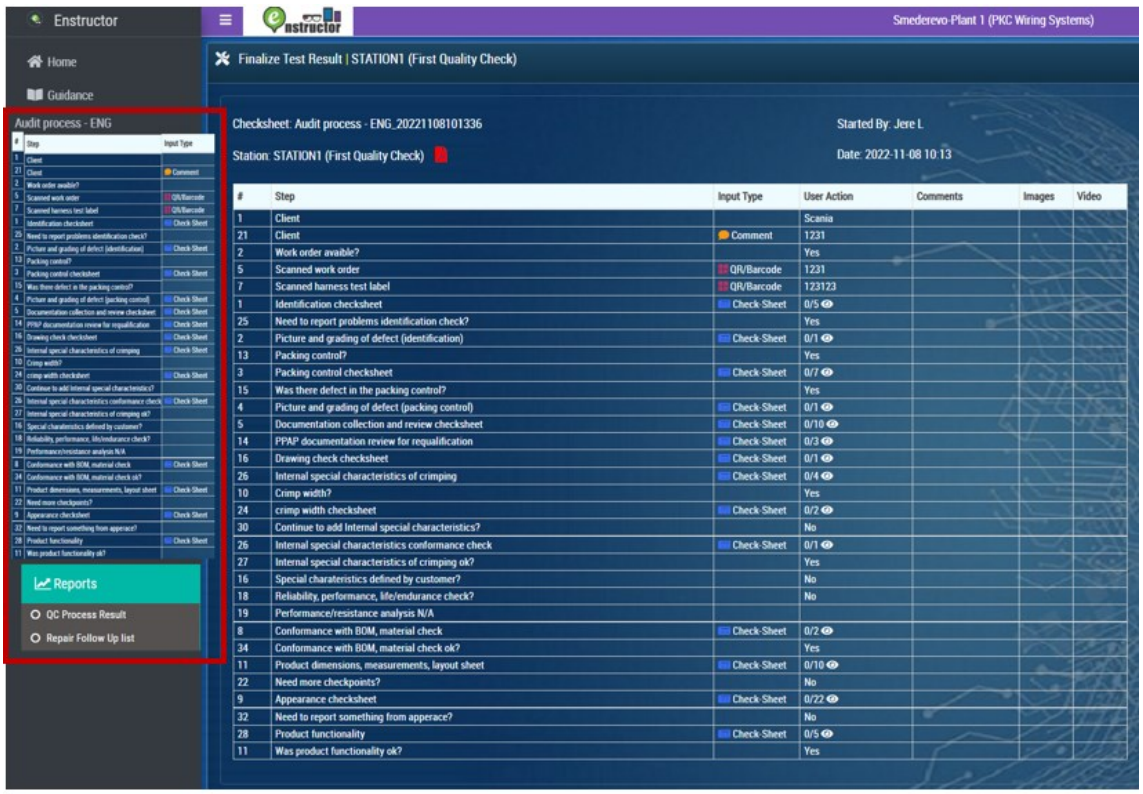


FIGURE 11. Add row functionality in use

As the number of rows is not limited, this allowed other measurement checksheets in product audit to be removed. That means the entire process structure became a lot lighter and easier to maintain as before we used six different sheets for measurements and now, we only need to use one.

4.3.3 Menu for Viewer side

The menu on the Viewer side is designed to make it easier for users to navigate. Previously, users had to go back using the arrow keys and answer each step. In addition to this feature, the quality team wanted the user to be able to see the previous result of the process for the customer whose process was opened. As before, the user had to log in to the designer side to view the results of the last process. The logic of the menu was designed to be as follows: when the first step of the process is opened, it is saved in the menu, and when the user moves forward in the steps, they are saved in the menu in order. This eliminates the possibility of the user skipping steps, as it would confuse the logical numbering of the steps. Figure 12. shows what the design looks like.



#	Step	Input Type	User Action	Comments	Images	Video
1	Client		Scania			
21	Client	Comment	1231			
2	Work order avaible?		Yes			
5	Scanned work order	QR/Barcode	1231			
7	Scanned harness test label	QR/Barcode	123123			
1	Identification checksheet	Check-Sheet	0/5			
25	Need to report problems identification check?		Yes			
2	Picture and grading of defect (identification)	Check-Sheet	0/1			
13	Packing control?		Yes			
3	Packing control checksheet	Check-Sheet	0/7			
15	Was there defect in the packing control?		Yes			
4	Picture and grading of defect (packing control)	Check-Sheet	0/1			
5	Documentation collection and review checksheet	Check-Sheet	0/10			
14	PPAP documentation review for requalification	Check-Sheet	0/3			
16	Drawing check checksheet	Check-Sheet	0/1			
26	Internal special characteristics of crimping	Check-Sheet	0/4			
10	Crimp width?		Yes			
24	crimp width checksheet	Check-Sheet	0/2			
30	Continue to add Internal special characteristics?		No			
26	Internal special characteristics conformance check	Check-Sheet	0/1			
27	Internal special characteristics of crimping ok?		Yes			
16	Special charateristics defined by customer?		No			
18	Reliability, performance, life/endurance check?		No			
19	Performance/resistance analysis N/A					
8	Conformance with BOM, material check	Check-Sheet	0/2			
34	Conformance with BOM, material check ok?		Yes			
11	Product dimensions, measurements, layout sheet	Check-Sheet	0/10			
22	Need more checkpoints?		No			
9	Appearance checksheet	Check-Sheet	0/22			
32	Need to report something from apperace?		No			
28	Product functionality	Check-Sheet	0/5			
11	Was product functionality ok?		Yes			

FIGURE 12. Design for menu in viewer side

The actual implementation was completely different from the design, as can be seen from Figure 13.

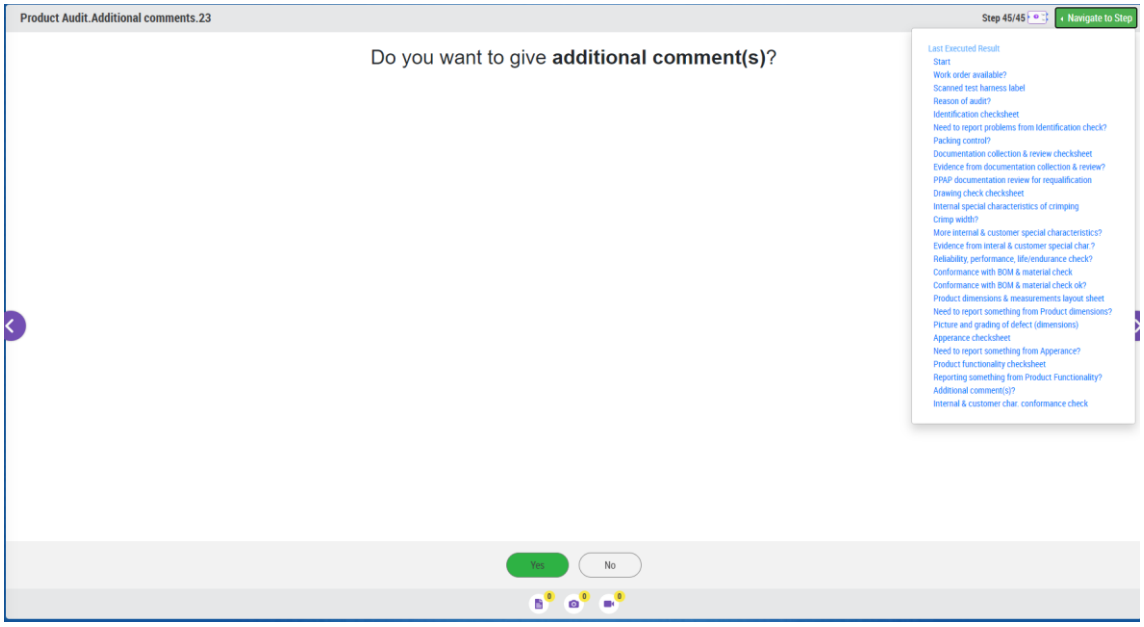


FIGURE 13. Final design for viewer side menu

As said before it is possible to see the last executed process from specific customer which process is opened. For example if you navigate to customer named ”Client 1”, you can only see previous result from the “Client 1”. If there are no previous results, the link is inactivated. You can see how previous result is seen by the eye of user from Figure 14, when “Last Executed Result” -button is clicked.

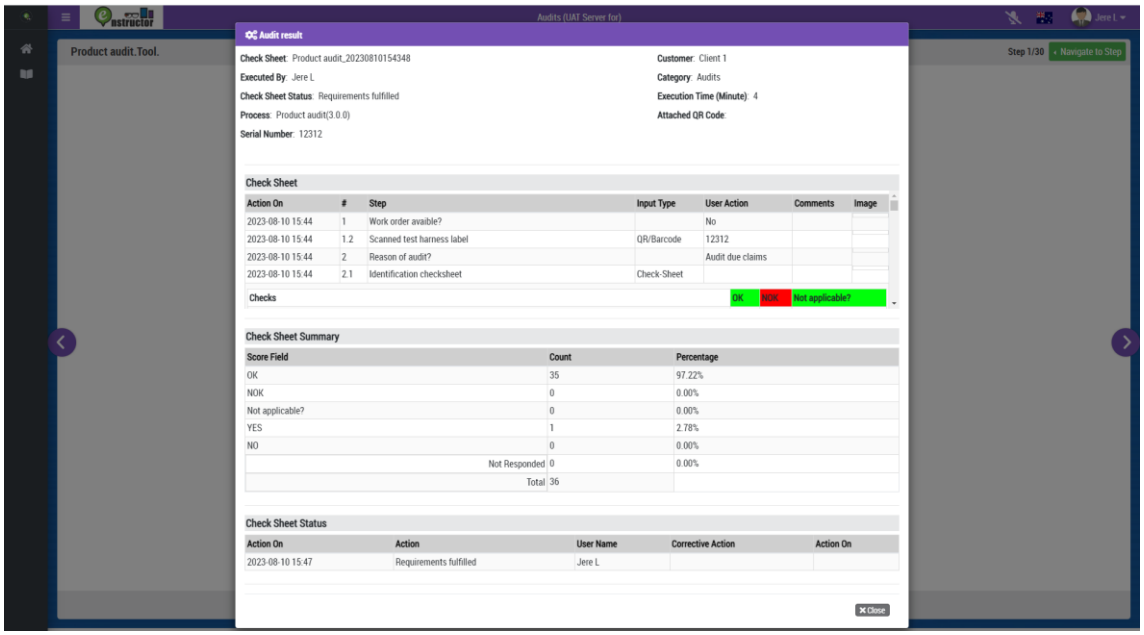


FIGURE 14. Last Executed Result from viewer side

4.3.4 Checksheet update for automatic result

Checksheets also received a major update when new functionality was added for automatic answers depending on what the user is answering. This was wanted to have for different measurements. The function was designed to recognize tolerances and nominal values and compare them to values given by the user. If the value was within the given tolerance, it would be marked as "OK," and if not, it would be marked as "NOK." This was designed to work as when the designer is doing the template for the checksheet and clicks “Measurement Template?" the Enstructor would automatically add the following columns to the checksheet:

- Nominal value,
- Tolerance,
- Measured value,
- “OK” -score field,
- “NOK” -score field.

From Figure 15., can be seen how the design looked.

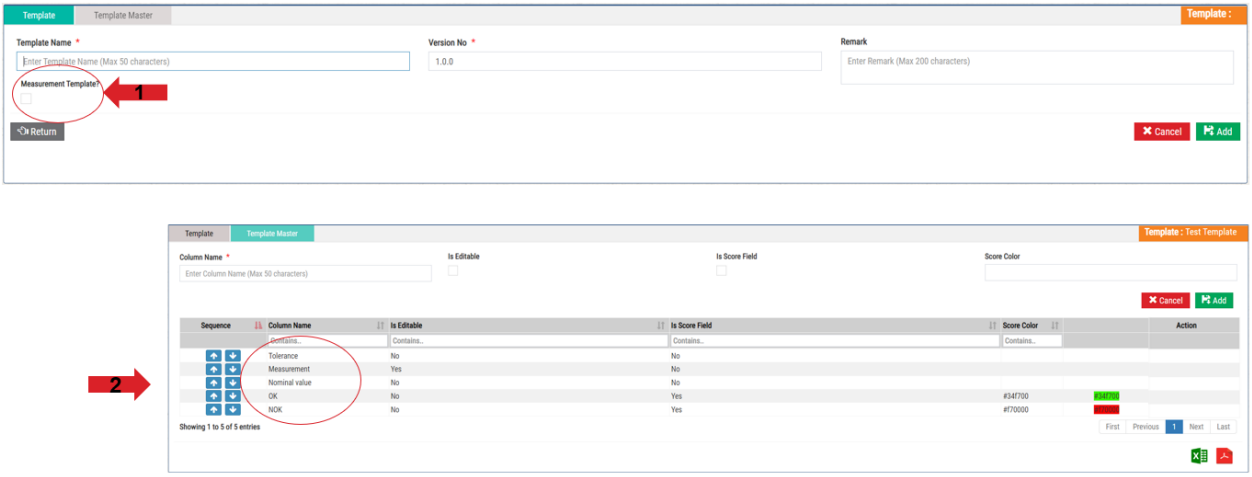


FIGURE 15. Checksheet measurement template

From the user (viewer) side the checksheet was designed to look like shown in Figure 16.

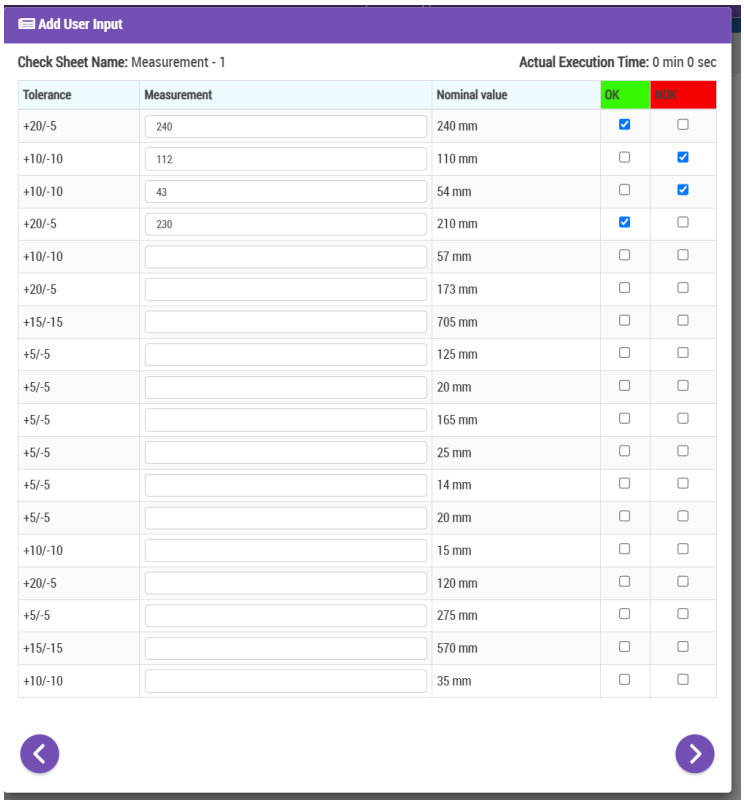


FIGURE 16. Measurement checksheet

The implementation was a lot different from what was designed. From Figure 17, can be seen how the actual implementation looks from the designer side.

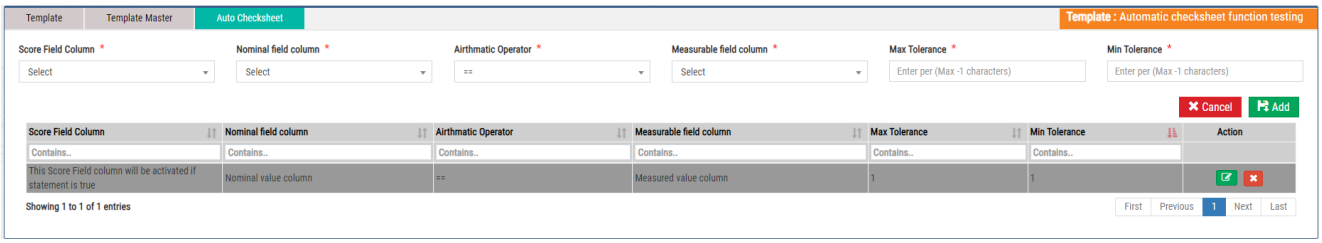


FIGURE 17. Auto Checksheet settings window

As can be seen from Figure 17, designers have the possibility to add column for nominal value and measured value. For addition designer can choose different score field column rather than “OK”. This allows larger flexibility and it’s easier to use with different languages. Working logic in this is that if user’s fillable value in “Measured field column” is between max and min tolerances, Enstructor will automatically tick the “Score field column" which designer has chosen to. Basically, could be said that the logic was the same as designed.

4.3.5 Mandatory picture or comment step

This step was wanted because it can be controlled so that the auditor will not just pass the step where additional information about a mistake or problem is asked. The design for this step was that it would be like a normal “text” step. The only addon would be that the Enstructor notices if the user has not given a picture or comment while being in step. The user would also not be giving final grading for the process because of that. Notification that pictures or comments were not given would be displayed after the step and at the end of the process. The Enstructor would give notification as designed in Figure 18.

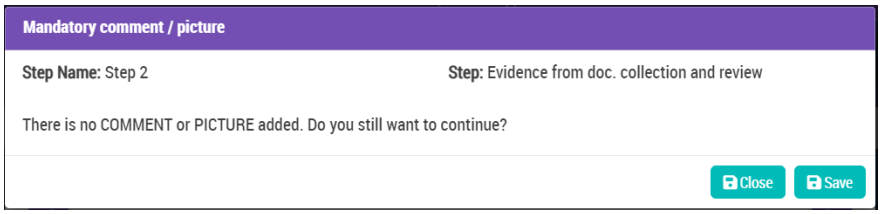


FIGURE 18. Mandatory comment or picture step notification

The implementation of this design was different only from the notification, as can be seen from Figure 19.

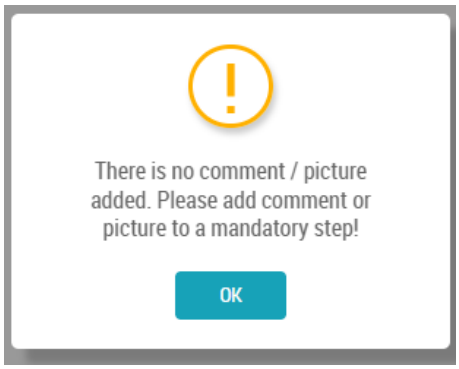
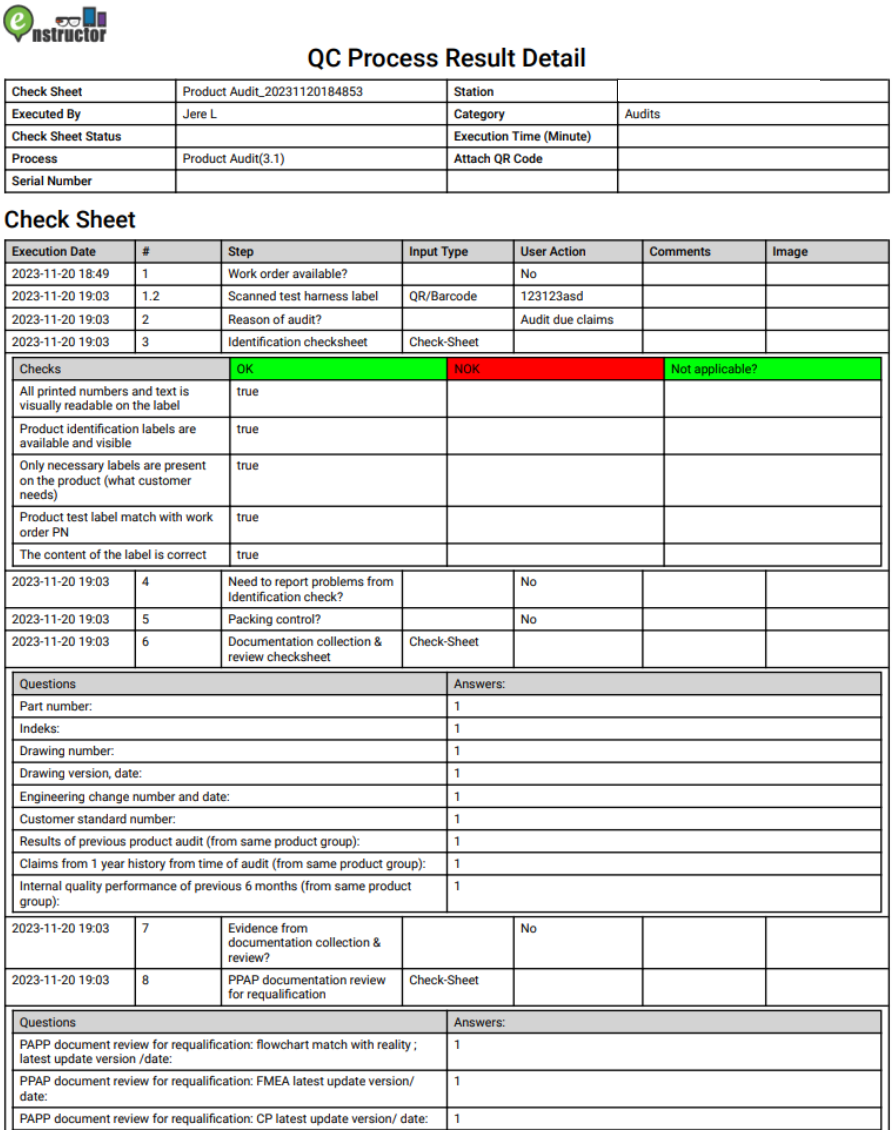


FIGURE 19. Notification window if picture or comment is not added

As an addon, the user cannot move forward in the step if a picture or comment is not given. When it was designed that, the Enstructor would check at the end of the process if a comment or picture was given to every “Mandatory Picture or Comment” step.

4.4 Ready product audit process in Enstructor

In this section, we go through what kind of audit process was designed to be and how it was converted from design to executor. The first idea for the product audit by the quality team was that Enstructor would fill up the existing PDF file, but this was not possible as Enstructor could not fill up PDF files; it would generate its own PDF file if the user wanted. From Figure 20, it can be seen in the PDF file that Enstructor generates.



QC Process Result Detail

Check Sheet	Product Audit_20231120184853	Station	
Executed By	Jere L	Category	Audits
Check Sheet Status		Execution Time (Minute)	
Process	Product Audit(3.1)	Attach QR Code	
Serial Number			

Check Sheet

Execution Date	#	Step	Input Type	User Action	Comments	Image
2023-11-20 18:49	1	Work order available?		No		
2023-11-20 19:03	1.2	Scanned test harness label	QR/Barcode	123123asd		
2023-11-20 19:03	2	Reason of audit?		Audit due claims		
2023-11-20 19:03	3	Identification checksheet	Check-Sheet			

Checks	OK	NOK	Not applicable?
All printed numbers and text is visually readable on the label	true		
Product identification labels are available and visible	true		
Only necessary labels are present on the product (what customer needs)	true		
Product test label match with work order PN	true		
The content of the label is correct	true		

2023-11-20 19:03	4	Need to report problems from Identification check?		No		
2023-11-20 19:03	5	Packing control?		No		
2023-11-20 19:03	6	Documentation collection & review checksheet	Check-Sheet			

Questions	Answers:
Part number:	1
Indeks:	1
Drawing number:	1
Drawing version, date:	1
Engineering change number and date:	1
Customer standard number:	1
Results of previous product audit (from same product group):	1
Claims from 1 year history from time of audit (from same product group):	1
Internal quality performance of previous 6 months (from same product group):	1

2023-11-20 19:03	7	Evidence from documentation collection & review?		No		
2023-11-20 19:03	8	PPAP documentation review for requalification	Check-Sheet			

Questions	Answers:
PAPP document review for requalification: flowchart match with reality ; latest update version /date:	1
PPAP document review for requalification: FMEA latest update version/ date:	1
PAPP document review for requalification: CP latest update version/ date:	1

FIGURE 20. Final result PDF generated by Enstructor

4.4.1 From idea to product

The idea of the product audit was first drafted diagrammatically to Microsoft Excel by the quality team. This draft was used as a basis for the whole Enstructor flow. From Figure 21, can be seen in the first part of the draft.

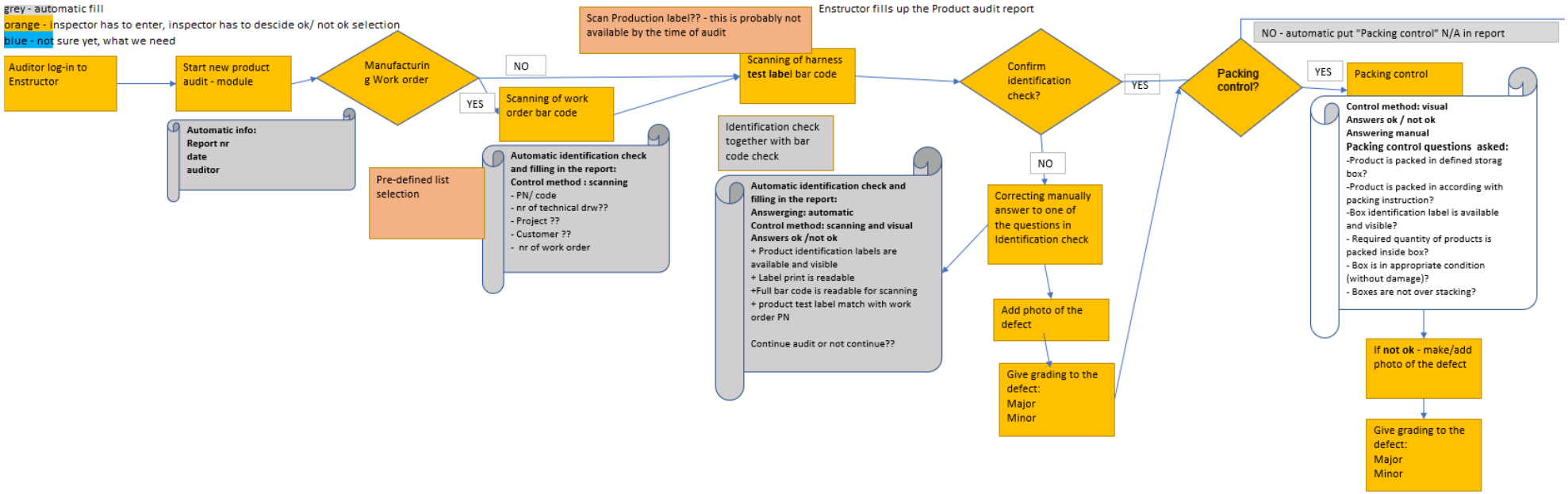


FIGURE 21. First part of original idea of the flow

It is good to understand the basic functions of the Enstructor before the next parts can be understood. The basic functions of Enstructor have been gone through in the appendices of this thesis. In the following chapters we will go through the implementation of the draft in Enstructor.

In the first version of the Enstructor process, the navigation path to open the product review process was not very clear to the user and there was no logic behind it. But since we were testing how the product check would be transformed into the Enstructor format, this was not given as much attention. As testing progressed on Enstructor, we thought about the navigation path and how it could be much cleaner and easier to understand for the user. This navigation path also affects the process itself, as each process in Enstructor is added under "Station", which is the client's name in the product audit navigation path. This allows you to sort the open product audit by customer, but still use the same process under each customer. This also helps a lot with process maintenance, as we can only use one process flow for each customer. The navigation path created for the finished product audit is shown in the figure below.

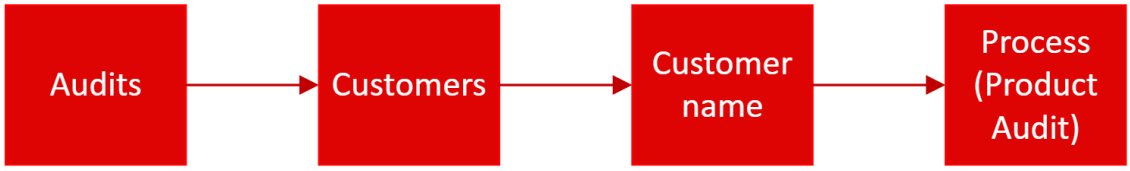


FIGURE 22. Navigation path for the product audit

If the customer's name is not present in the list of customers, there is one process called "Unidentified customer" in which the customer's name is asked in the first step of the product audit process. Otherwise, the process is same as "normal" product audit.

Next, we will go through the latest version of the product audit, which has been implemented in production. Because the whole product audit is so complex, we will focus only on the key points.

It's good that there is some logic behind the step numbers, because they are displayed in the final results window. This was a bit tricky, because if, for example, two steps have the same step numbering, it wouldn't be very logical. This was handled as follows: if the step is the "main step", where the user is anyway, the step number is an integer, for example the number "6". If the step is a "middle step", where the user may be in some cases, this step is numbered with the number of the

main step and a dot followed by a sequence number. For example, '6.1' and '6.2' followed by the main stage number '7'. This logic is shown in Figure 23.

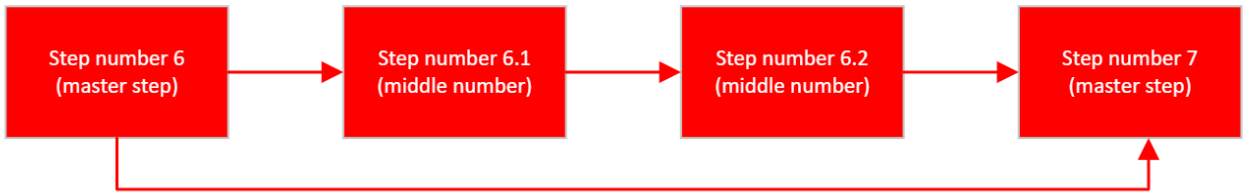


FIGURE 23. Logic behind step numbers

As an addon in the newest product audit version, every step has been added under phases, so the user knows in which phase of the audit they are. This can be seen from the left top corner of the step, as shown in Figure 24. In the information shown, users will see the name of the process, which is “Product Audit” and name of the phase which in that stage of the process is “Reason of audit” and numbering of step which in this step is number “2”.

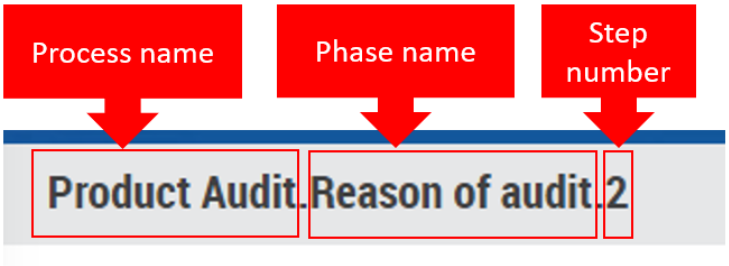


FIGURE 24. Phase name

There are some QR or barcode reading steps in product audit. Example work order and harness test label are scanned by using step with scanning possibility, as shown in Figure 25.

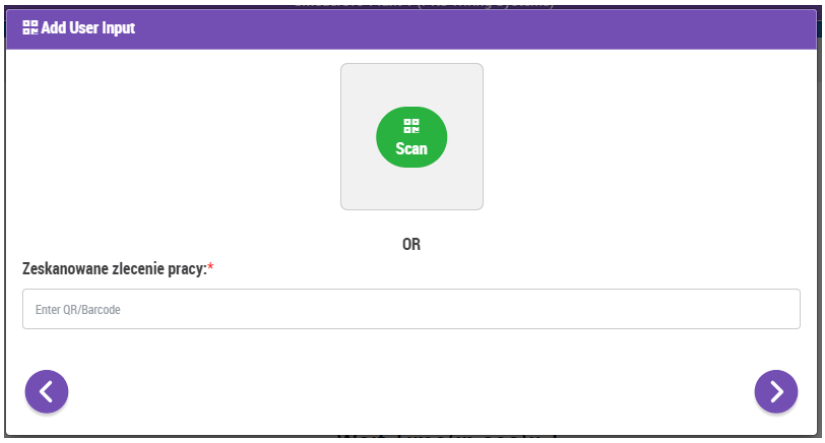


FIGURE 25. Scan work order step

With the newest update to the Enstructor, we also received some logic behind this QR/barcode reading. If the user uses his device's camera to read the code, the Enstructor will detect this and add text to this step, which is saying "QR/barcode read by camera," as can be seen from Figure 26. This indicates to the user that, for example, the label on the harness was in such a condition that it was readable with the camera. If the user manually inputs something in the box, for example, a work order number, the text is not added to this step's "Comment" section. This is one of the checkpoints in the product audit, and computer confirmation is always good to have; even the label is checked visually.

#	Step	Input Type	User Action	Comments	Images	Video
1	Work order available?		No			
1.2	Scanned test harness label	QR/Barcode	6419800052722	QR/barcode read by camera		

FIGURE 26. QR/Barcode read by camera

In the newest product audit Enstructor flow, the quality team wanted the reason for the audit would also be able to be chosen by the auditor. So, there was added "reason of audit" as a step after

“harness test label reading”, in which the user needs to choose the reason from three different options for the audit, as can be seen from the figure below.

FIGURE 27. Reason of audit

In product audit there are a lot of basic checksheet steps. One example is shown below.

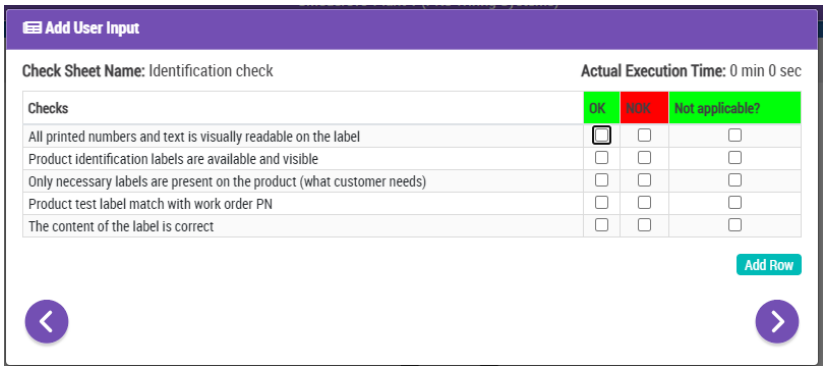


FIGURE 28. Identification check

As Enstructor does not have the option to automatically redirect the user to a specific step if, for example, “nok” is answered in the checksheet, a step where the user was asked if there were any

findings in the step was needed to be added, as shown in the figure below. This step is after every checksheet.

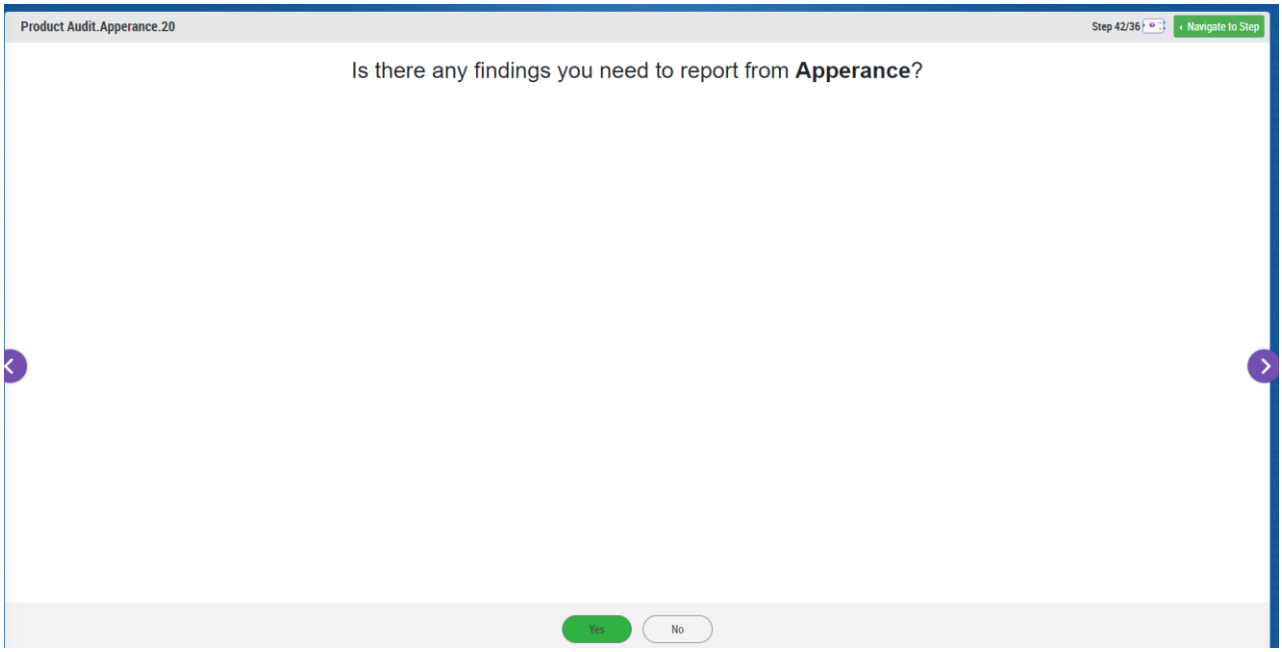


FIGURE 29. Any findings to report

If the user answers this question “Yes”, user will be redirected to step where is asked to give comments or picture. These are mandatory and if a picture or comment is not added, user is not let to go forward. When the user goes forward, he will be asked to give grading of the finding. Example of this grading is shown in Figure 30. These defect gradings (major / minor) are used in product audit’s grading method.

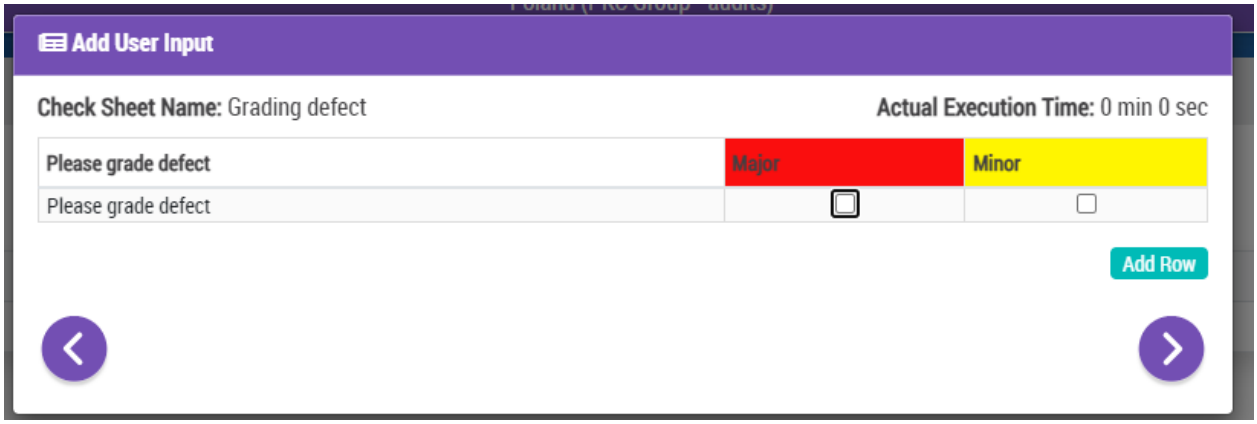


FIGURE 30. Grading of defect

What comes to grading, we made following grading statements for product audit:

1. If user answers at least one “Major” or more than 3.333% percentage of answers are “Minor”, result of the process will be “Requirements not fulfilled”.
2. If user answers are less than 3.333% “Minor” answers, result of the product audit will be “Requirements conditionally fulfilled”.

These grading statements can be seen in Figure 31.

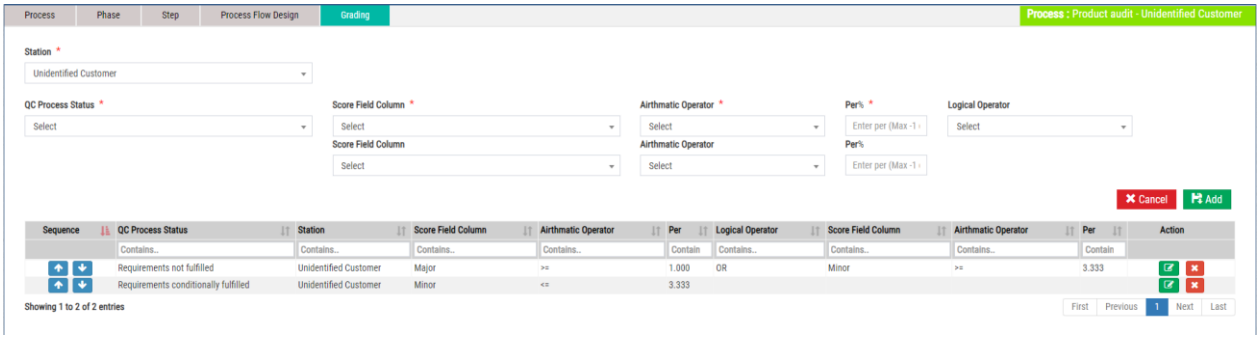


FIGURE 31. Built-in grading statements

4.4.2 Test in Starachowice, Poland 06.07.2023

A test for Enstructor 6.0 was done at PKC Group’s plant in Starachowice, Poland, on July 6, 2023. The first thing that was found was a problem with the connection. There were spots where the WiFi connection could not reach so well. A couple of bugs were found during this testing day. These bugs were the following:

- The wait time in the wait element was a lot more than 250 milliseconds. It was more than 6 seconds.

- “Add row” functionality was not working as wanted. It was not automatically counting column numbers.

- The QR/ barcode function worked, but the reading area was not focused on the right spot.

- The menu for viewers worked, but it was reducing the steps if the user jumped back in steps before the end.

There were also some modifications wanted for the audit process itself. There is an “Internal Special Characteristics of Crimping” checksheet where the quality team wanted to add two additional points, “Terminal” and "Wire". This change can be seen in Figure 32.

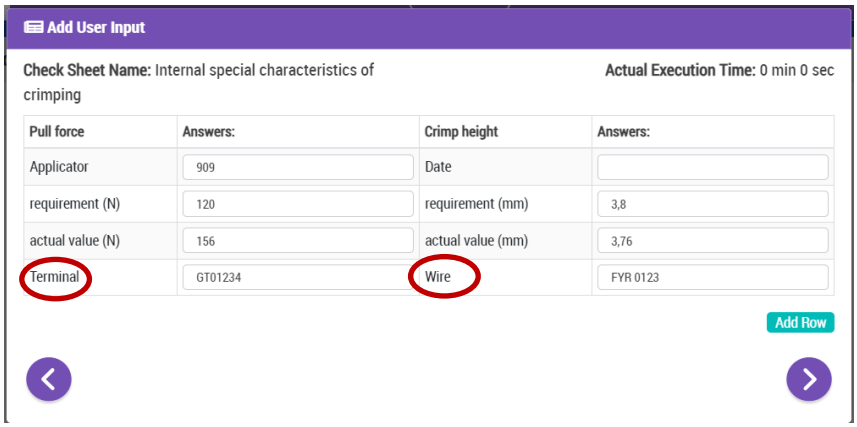


FIGURE 32. Internal special characteristics of crimping

For the “Product Dimension, Measurement Layout” checksheet, the quality team wanted to add the “Reference Point” column, which would allow other teams to use different referring points, as the point now used is based on numbers. The Serbian team prefers marking referring points using the following method: from XS.1 to YX.2.1. That is why “reference point” was added to the product dimensions and measurements checksheet. This allows greater flexibility for different teams to use the same dimensions checksheet, which is shown in Figure 33. This sheet was also modified to make auditors lives easier by automatically generating the next row number after the auditor clicks the “Add Row” button. This will make it faster to fill up this sheet, as the auditor can only use as many points as there are in the harness.

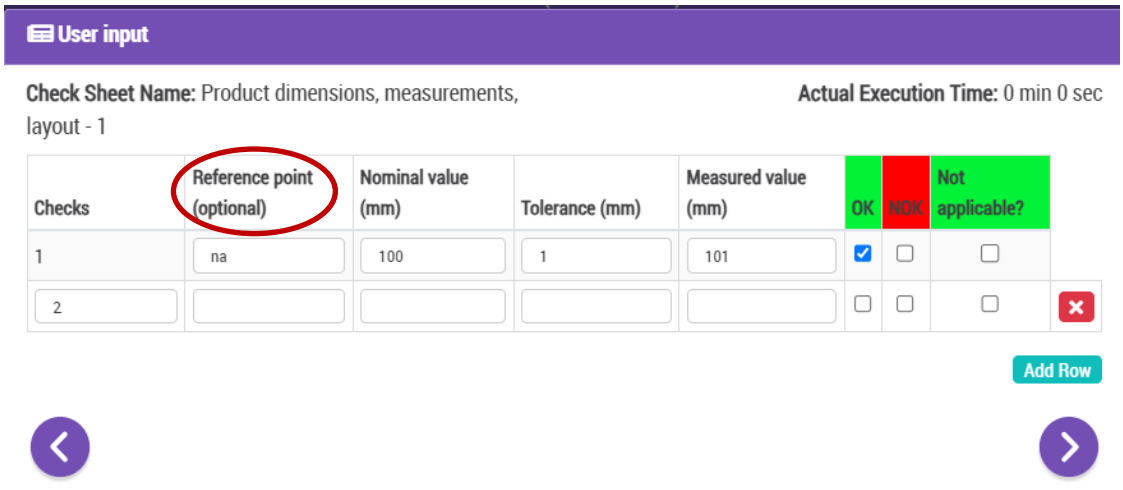


FIGURE 33. Product dimensions sheet

One of the most annoying things was the QR code reading problem, as the reading itself worked great, but the area where the user needed to have the QR code was in the wrong place. This created a lot of frustration when the QR code needed to be in the exact location for the reading to work correctly, as shown in Figure 34.

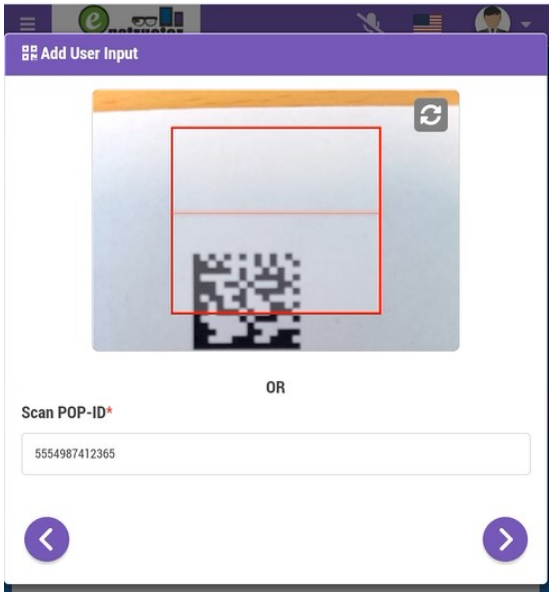


FIGURE 34. The QR code reading issue

This was solved by decreasing the area which the camera uses. As shown in Figure 25. With this modification everything started to work perfectly. As we use this application mainly with handheld devices, this was the perfect fix for this problem.

The latest but not least bug or problem that auditors noticed when doing the test was that the menu for the user was “deleting” the steps from the menu if the user jumped back. This was tricky as the Enstructor does not know if the user decides to go back and then chooses a different path by answering differently than before. The Enstructor will save the path and those steps if a different path is not selected, which means different answers to questions are not answered. In Figure 35, you can see this menu structure.

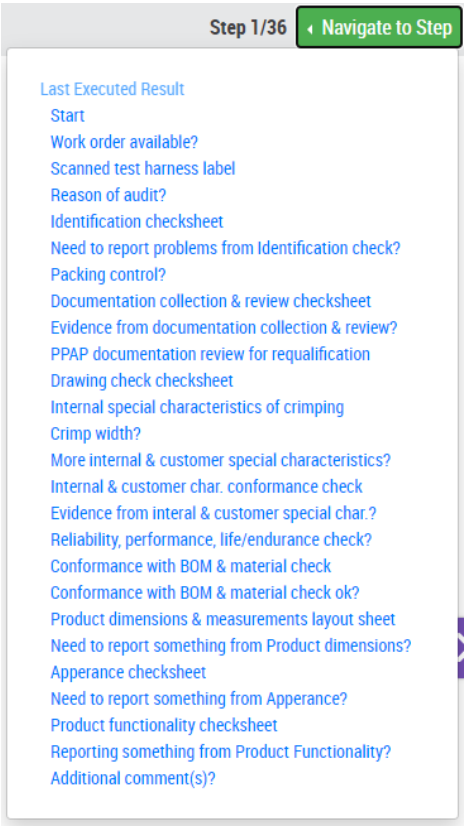


FIGURE 35. Menu for the user

Overall, the testing went well, and new development ideas for the product audit came to mind. There were also some requests for a change, mainly related to the list of measurements; for example, if the "nominal measurements" of certain customers could already be loaded into the list when the process is opened. In principle, this is possible if processes are made customer specific. This would also allow for customization of the product audit process, as some customers may have different requirements that, for example, other customers do not require or need. There is only one major problem with this implementation, at least in terms of the measurement table. In general, one customer does not have only one specific product, but there are usually hundreds of product variants. This would mean that there would have to be hundreds of different processes under one customer where only the measurement table would be different. This would be moderately difficult to maintain and update all the processes.

5 FUTHER DEVELOPMENT OPPORTUNITIES FOR ENSTRUCTOR

We are already working on new development proposals for the Enstructor. Many users want to analyze the data that is generated in Enstructor, and Enstructor currently only allows the detailed data export of a single process. That is why we are already making plans to add data analysis inside Enstructor. Now data is analyzed by using a Python script that takes all wanted data from a single process and then makes wanted graphs out of it.

Maintenance is one of the biggest and most important things when it comes to manufacturing. When machines are not moving, that will affect the productivity of the factory. That's why we are also developing maintenance tools to be part of Enstructor. This would combine easy-to-make instructions with an example tool for service management (12.).

During the thesis, we also developed various other auditing processes (in addition to product auditing) to fit the Enstructor format together with the quality team.

Because the Enstructor is so easy to use and flexible, you could say that only your imagination is the limit when it comes to development and the Enstructor.

6 SUMMARY

This thesis was done for PKC Group Ltd. The subject of this thesis was to create a product audit application for Enstructor together with the quality team. The intention was that in the future, product auditing in European and South American factories would be handled exclusively by Enstructor. In addition, other possible uses for the Enstructor application were explored, and various test versions were made during the thesis. The possibilities for using Enstructor are almost endless, as mentioned earlier in this thesis.

There were also challenges in doing this work. With the latest updates, a few problems appeared in Enstructor. Working with the MTSL to fix these problems was certainly one of the most challenging parts of doing this thesis. For example, one problem was that Enstructor stretched the images over the menu elements. When the problem was investigated, it turned out to be a width issue. Since my screen width was over 19" and the programmers were less than 19", the root cause of the problem was not immediately discovered. Nor was the programmer able to replicate the problem on his own machine.

The result of the thesis can be said to have been a success, as the product audit application is now in use in our factories in Europe and South America. In addition, new plans for the development of Enstructor have been initiated and, for example, various auditing processes have already been created and tested in the Enstructor form.

REFERENCES

1. PKC Group 2023. About PKC Group. Search date 27.07.2023. https://www.pkcgroup.com/about-pkc-group.html.

2. PKC Group 2023. Internal source. Search date: 29.07.2023.

3. Pesonen, Herkko 2007. Asiantuntijaorganisaation laatuopas. Juva: WS Bookwell Oy.

4. Lecklin, Olli 2006. Laatu yrityksen menestystekijänä. Hämeenlinna: Karisto Oy.

5. ISO 9001:2015 & IATF 16949:2016. Quality management systems. Search date 22.11.2023. Internal document.

6. IONOS 2023. The PDCA cycle: more success with the Deming cycle Search date 22.11.2023. https://www.ionos.com/startupguide/productivity/pdca-cycle/.

7. SFS 2023. Mikä on standardi. Search date 28.07.2023. https://sfs.fi/standardeista/mika-on-standardi/.

8. ASQ 2023. What are quality standards? Search date 25.08.2023. https://asq.org/quality-resources/learn-about-standards.

9. PKC Group Oy Intranet.

10. Hoyle, David 2005. Automotive Quality Systems Handbook: ISO/TS 16949:2002 Edition. Oxford: Butterworth-Heinemann.

11. VDA Volume 06 Part 5 03/2020. Quality Management in the Automobile Industry. Part: 5. Product Audit. https://webshop.vda.de/QMC/en/volume-06-part-5_032020. Requires buying.

12. The Importance of Maintenance 2023. Search date 27.11.2023. https://www.automationmag.com/images/stories/LWTech-files/94%20Intelligent%20Systems.pdf.

13. User Manual for Web Portal of Enstructor System 2023. Search date 27.11.2023. Internal document.