FHS PERSONNEL TRAINING, EXAMINATION AND KNOWLEDGE EVALUATION – FURTHER DEVELOPMENT OF SIPEC PRO E-LEARNING INFORMATICS SYSTEM

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Abstract

The need for newly-hired personnel education in CANDU research field and training for performing specific workplace activities in Out of Reactor Testing Department, at the Institute for Nuclear Research Pitesti led to the development of the Training, Examination and Knowledge evaluation SIPEC Pro e-learning Informatics System. The courses have been fully elaborated in the Out of Reactor Testing Department. SIPEC Pro e-learning System consists of seven courses grouped in a standalone database, each course being composed of an introduction in subject of matter along with general concepts about CANDU Nuclear Reactors, followed by the main information of the course, presented textual or graphic as images, one chapter for synthesis, conclusions, references, and a final interactive test. Until 2020 only one course had an explanatory video which described Snout Plug operation and its removal from the Fuelling Machine Magazine. Additionally, in 2020 several more videos for Shield Plug and RAM Adapter operation were created. This method is better than the classic learning, noticing that involved personnel were able to appropriately understand the CANDU Fuelling Machine operation principles through video visualization than examining 2D drawings. Further plans are to expand SIPEC Pro for other Fuelling Machine tools/devices or Sub-assemblies.

Keywords: *Fuel Handling System, CANDU, Shield Plug, SIPEC Pro, E-learning*

Introduction

One of the RATEN ICN objectives is the continuous learning, consolidating, and maintaining the professional knowledge required for CANDU research and to operate current testing equipment. In order to achieve this, inside Out of Reactor Testing Department was developed SIPEC Pro informatics system, mainly focused on the Fuel Handling System operation activities and exploitation, its purpose being the personnel training, examination, and knowledge evaluation.

This interactive e-learning system allows an efficient knowledge accumulation regarding Fuel Handling System, all its courses being sufficient for understanding treated subjects, reducing the documentation time. SIPEC Pro informatics system was developed in Toolbook Instructor 9.5, a software specialized in creating interactive content, quizzes assessments and simulations. Some of these options were utilized in creating an optimal course, its interface providing navigation buttons ("forward", "backward", "menu"), interactive table of contents, textual data, pictures and questionnaires which specify the correct/ wrong answer for every quiz.

Toolbook Instructor 9.5 software is mainly composed of two operation levels: "author level" and "reader level". First level, "author level" is the environment where the application is created, developed, and modified using different tools such as tool bars, templates, graphic elements catalogue and various colors. Also, at this level, the developer can create objects and modify their properties, appearance, and behavior. Likewise, "reader level" is the environment where created courses can be tested during development stage, and where users can interact with the final created e-book, navigate to any page inside the course, can read texts and answer quizzes.

SIPEC Pro – Up-to-now developed Courses

The first developed SIPEC Pro interactive course was "Fuelling Machine Auxiliary devices – Snout Plug". Later on, the need to fully explain the CANDU Fuelling Machine construction and operation, several courses regarding its sub-assemblies were also created: "Fuelling Machine Snout assembly", "Fuelling Machine Magazine", "Fuelling Machine Separators", and "Fuelling Machine RAM assembly". In 2017 the fuelling/refuelling process was described in "Fuel Handling System – Fuel transfer equipment" course. The last course was developed in 2020, "Fuelling Machine Head - Specialized tools and devices", in which the Shield Plug, FARE Tool, Channel Closure, Guide Sleeve, Insertion Tool, and RAM Adapter are presented.

Fuel Handling Machine Auxiliary Devices – Shield Plug

During 2020, SIPEC Pro System was expanded with "Fuelling Machine Head – Specialized tools and devices", one of the topics covered being the CANDU Shield Plug.

For every CANDU fuel channel assembly there are two Shield Plugs positioned where the end-fitting pierces the reactor end shield. In Fig. 1, the CANDU Shield Plug is presented. Additionally, RAM B, RAM Z, RAM C, fuel channel end fitting and liner tube are also shown.

Its main functions are, as follows: providing a radiation shield at either end of the channel assembly, providing means of locating the fuel bundles in the channel, and holding the fuel bundles inside the fuel channel when the channel closures are removed.

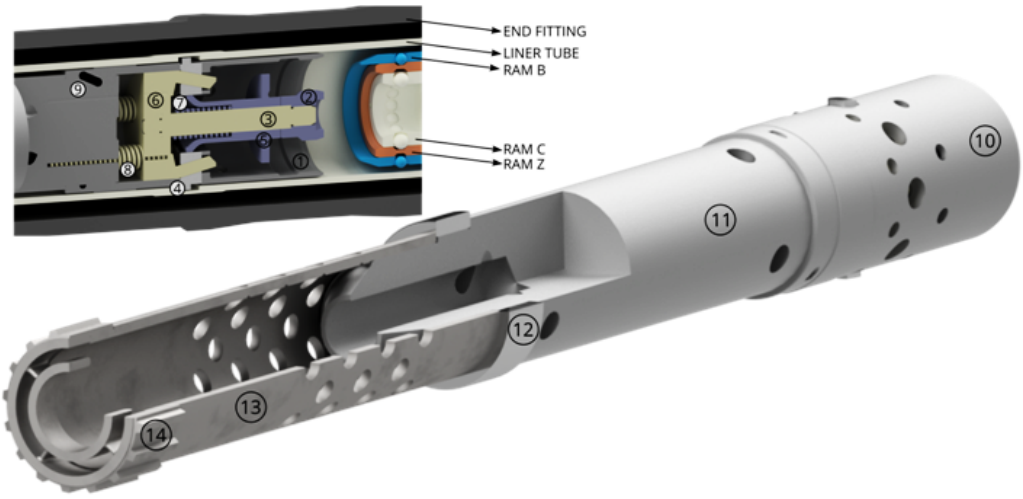


Fig. 1. CANDU Shield Plug
The main components are: 1- Casing; 2 - Stem end; 3 - Spider stem; 4 - Jaw; 5 - Safety latch; 6 - Spider; 7 - Safety spring; 8 - Spider spring; 9 - Roll pin; 10 - Latch Assembly; 11 - Shield body; 12 - Wear ring; 13 - Flow Tube; 14 - Fuel adaptor

The most important parts of the Shield plug are the Latch mechanism assembly, Shield body and Fuel Adaptor. The Fuel Adaptor is the part that gets in contact with the fuel assembly end plate, and is specially machined to support the fuel column inside the fuel channel.

The center section of the Shield Plug, called Shield body (item nr. 11 on Fig.1.) is made of 410 Stainless Steel and serves as radiation shield [1].

The Latch mechanism assembly (shown in the upper left of Fig.1.) is basically a spider finger and jaw mechanism. The most important part of the Latch mechanism is the Spider stem assembly (item 3 and 6 on Fig.1.) which moves back (from right to left in Fig.1.) in order to retract the Shield Plug locking jaws and forth (from left to right in Fig.1.) to expand the same jaws.

The back movement of the Spider stem assembly is achieved with the RAM assembly after it enters inside the Latch assembly.

First step is the 12.7mm advancing of RAM Z in order to lock RAM B onto the Shield Plug casing (item 1 on Fig.1) and RAM C to the Stem end (item 2 on Fig.1). Through this advancing, RAM Z unlocks the safety mechanism of the Shield Plug (item 7 and 5 on Fig.1.) – in this moment the Jaws are still expanded outside the Shield Plug. To retract the Jaws, RAM Z needs to advance additionally 21.082 mm, carrying RAM C with it and depressing the Spider stem until fully retraction of the Shield Plug Jaws.

The Spider stem assembly forward movement is achieved after the RAM Z is retracted, the Spider springs (item 8 on Fig.1.) pushing the Spider stem in its original position.

The Shield Plug is designed such that its handling and maintenance to be kept to a minimum. When removed from the reactor, the Shield Plug is highly active, especially on the Fuel adaptor end. In case of malfunction, the faulty Shield Plugs are sent to the fuel storage bay with a recommendation not be handled, maintained and reused [2].

When discharging an unserviceable Shield Plug at the Discharge Bay via Spent Fuel Port and Ladle, a special tool called SPLM (Shield Plug Locking Mechanism Assembly) is used to keep the Jaws retracted. This tool is installed by the Fuelling machine into the Shield Plug.

Further development of the SIPEC Pro through incorporation of Explanatory Videos

It is known that most of the CANDU information is constituted of textual data and graphically as pictures. One of SIPEC Pro main goals is the personnel training in the CANDU Fuelling Machine field using explanatory videos visualization, a more suitable method to understand the Fuelling Machine sub-assemblies moving parts in order to execute specific jobs, the components behavior and their interaction with the auxiliary devices.

As stated before, SIPEC Pro had only one educational video on the Snout Plug operation included in "Fuelling Machine Auxiliary devices – Snout Plug" course created in 2012.

After noticing promising results using this learning method, it was decided to expand the graphical database for other Fuel Handling Machine devices, so there were created explanatory videos for Shield Plug removal from End-fitting, Shield Plug installation in Magazine Tube ("H" or "M"), RAM Adapter installation in "J" Magazine Tube, and RAM Adapter picking from "J" Magazine Tube.

All these videos were created in Autodesk Inventor Studio, an environment included in Autodesk Inventor main software that ensures graphic processing such as rendering images or creating animations with the parts/assemblies previously drawn.

Prior to the developing stage of these videos, the technical documentation regarding sequences and jobs carried out by the Fuelling Machine Head for the operations needed to operate the auxiliary devices Shield Plug and RAM Adapter was thoroughly studied.

These animations created with Autodesk Inventor Studio were later edited in Movavi Video Editor, in order to introduce the Fuelling Machine Sequence description (positioned in the upper part of the video interface), steps codes executed (lower part of the video interface) and their explanation (as example, CRBW: Move RAM B to Position W).

The media player supported by Toolbook Instructor has typical control buttons such as "play", "pause", "stop", "mute volume", one slider for volume adjusting (this feature was not required), and elapsed time visible on the screen.

One example of explanatory video created to further develop the SIPEC Pro system and included in "Fuelling Machine Head – Specialized tools and devices" course is the "Shield Plug removal from End-fitting", some of its frames being shown in following Fig.2. to Fig.6.

For better understanding of the process, only important parts for this operation were shown in the video such as RAM B, RAM Z and RAM C, liner tube besides the Shield Plug, as shown in Fig.2, which presents the moment before RAM Head being inserted in the Shield Plug.

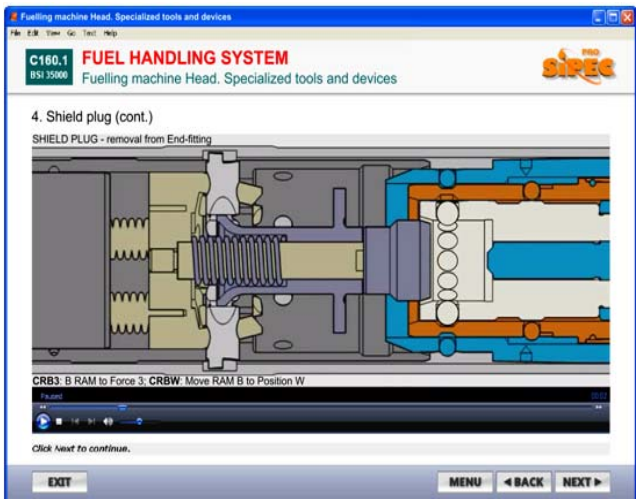


Fig. 2. Shield Plug removal from End-fitting – second 00:02 frame

Fig.3. presents the Shield Plug removal from End-fitting – second 00:07 frame showing the moment where RAM Head is inside the Shield Plug, but before the operation of RAM B locking into Shield Plug Casing grove.

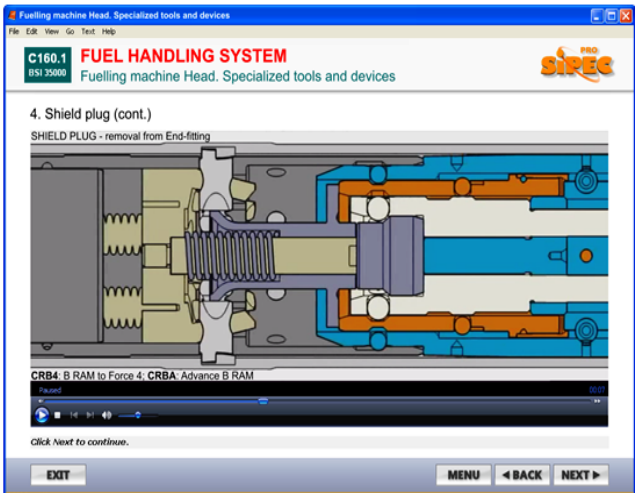


Fig. 3. Shield Plug removal from End-fitting – second 00:07 frame

Shield Plug removal from End-fitting - second 00:09 frame is presented in Fig. 4, making visible the moment where the Safety latch is pushed back (from right to left) in order to free the locking jaws. It is also visible that RAM B is locked onto the casing through RAM Z advancing.

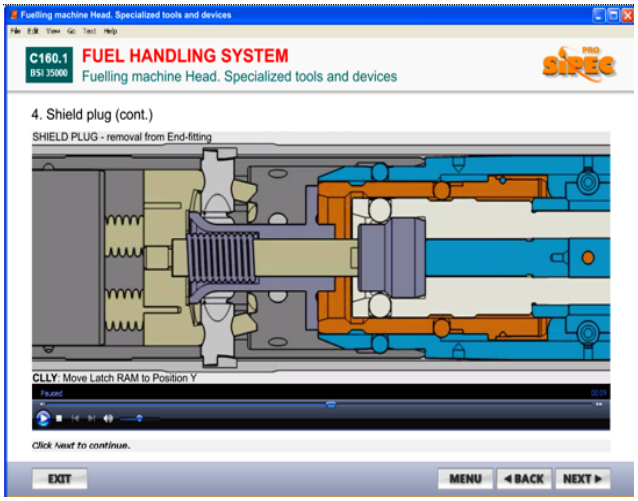


Fig. 4. Shield Plug removal from End-fitting – second 00:09 frame

Fig.5. presents the Shield Plug removal from End-fitting – second 00:13 frame, showing the moment where the Jaws are fully retracted through additional RAM Z advancing.

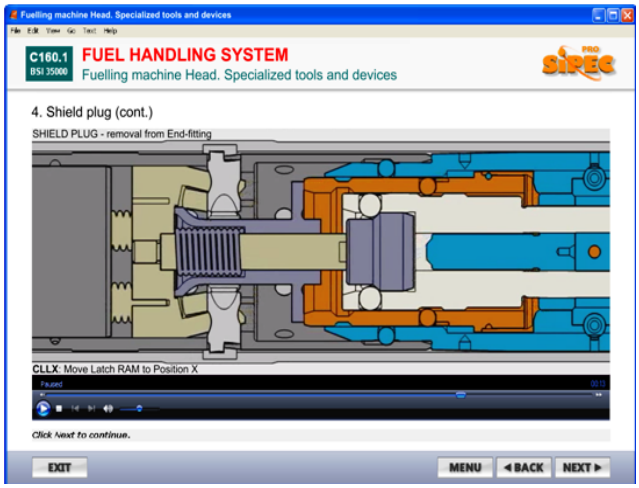


Fig. 5. Shield Plug removal from End-fitting – second 00:13 frame

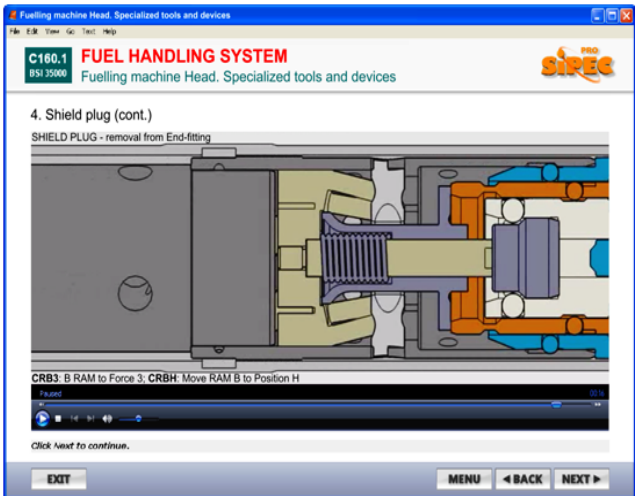


Fig. 6. Shield Plug removal from End-fitting – second 00:16 frame

The Shield Plug removal from End-fitting – second 00:16 frame is shown in Fig. 6., presenting the extraction of the Shield Plug from the liner tube executed through completion of step code CRBH: Move RAM B to Position H.

Conclusions

After the further development of SIPEC Pro informatics system resulted following explanatory videos: "Shield Plug removal from End-fitting", "Shield Plug installation in Magazine Tube (H or M)", "RAM Adapter installation in J Magazine Tube", "RAM Adapter picking from J Magazine Tube", being added to priorly created "Snout Plug removal from A Magazine Tube and installation in Snout Assembly".

This updated version of SIPEC Pro interactive courses was run and tested by the newly hired personnel in Out of Reactor Testing Department, again, positive feed-back being received after its completion.

In the near future it is recommended further development and update of already existing SIPEC Pro courses to include explanatory videos, especially for the Fuelling Machine Sub-assemblies. As a particular example, the "Fuelling Machine RAM assembly" course can be updated to include an animation for RAM B and RAM Z drive mechanism explanation.

This interactive learning platform could be furthermore expanded with courses for other types of reactors/nuclear facilities or components, such as Generation IV ALFRED Reactor Fuelling Machine after comprehensive research.

References

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