

# ADVANCED OPERATOR INTERFACE DESIGN FOR CANDU-3 FUEL HANDLING SYSTEM

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## **ABSTRACT**

*The Operator Interface for the CANDU 3 Fuel Handling (F/H) System incorporates several improvements over the existing designs. A functionally independent sit-down CRT based Control Console is provided for the Fuel Handling Operator in the Main Control Room. The Display System makes use of current technology and provides a user friendly operator interface. Regular and emergency control operations can be carried out from this control console. A stand-up control panel is provided as a back-up with limited functionality adequate to put the F/H System in a safe state in case of an unlikely non-availability of the Plant Display System or the F/H Control System. The system design philosophy, hardware configuration and the advanced display system features are described in this paper. The F/H Operator Interface System developed for CANDU 3 can be adapted to CANDU 9 as well as to the existing stations.*

## **INTRODUCTION**

The Fuel Handling (F/H) System in existing CANDU 6 plants was designed in the early 1970's utilizing the technology available at that time. The system was designed to be operated in full automatic mode through a single centralized computer system, which performs both the control and display functions. The F/H control computer system is shared with one of the main plant control computers (DCC-Y). In order to ensure continuity of F/H operations during the possible unavailability of the control computer system, a full manual back-up control panel was provided using discrete hardware (such as relays, current alarm units, analog controllers etc.). This is a stand-up panel and provided the operator interface through hardwired switches, push buttons and indicators. Two sets of CRT's (Cathode Ray Tubes), alphanumeric keyboards and function keyboards are provided on this panel for automatic supervisory control when the control computer is available. One printer is provided for logging of alarms, events, operator commands and sequences. Independent closed circuit TV (CCTV) monitors are used to visually monitor the Fuelling Machine in the reactor vault.

The control and display software was written in Assembly language and highly skilled computer engineering staff are required to maintain the software. The CRT displays are primarily text based. This design has proven to be adequate in meeting the basic control and display requirements. However, the sharing of the F/H control and display computer with the main plant control computers has resulted in some operational limitations for enhancing the operation of the F/H system.

The CANDU 3 F/H system design and operation are conceptually different from the CANDU 6 system. The CANDU 3 F/H system is based on a single ended re-fuelling method and is controlled by a dedicated F/H distributed control system. The normal F/H operations are carried out from a sit-down operator's console with multiple CRT's. The stand-up control panel provides only limited control and monitoring functions pertaining to the safe state of the F/H system and is not designed to be used for the normal F/H operations. The Operator Interface design considers these differences in the system design.

## **DESIGN PHILOSOPHY**

The design of the CANDU 3 F/H Operator Interface System is based on the latest available technology utilizing the standard off-the shelf hardware and software to the maximum possible extent. The system design is based on the following primary design decisions:

1. Provide a functionally independent F/H Operator Interface. This facilitates maximum flexibility for operation and maintenance of the F/H system with minimum impact on the rest of the plant Operator Interface System. This is also in line with the current design practice at multi-unit CANDU stations such as Bruce and Darlington where the F/H Operator Interface System is de-coupled from the rest of the plant Operator Interface System.
2. Since a dedicated F/H distributed control system is being used, the functionality of the display computer systems will be limited to Operator Interface functions only.
3. Operator Interface Design must meet the CANDU 3 Human Factors requirements.
4. Provide an easy to use and user-friendly system.

Even though the F/H Operator Interface System is functionally independent, it will still be part of the overall plant wide Operator Interface System which is designed to meet the following criteria:

1. To provide high reliability and availability with dual redundant computer system configuration.
2. To use the currently available and proven off the shelf hardware and software meeting the international open systems standards to the maximum extent possible.
3. To use the advanced programming and display design tools to improve design and development efficiency and facilitate simpler and faster system maintenance.

One of the primary goals of the CANDU 3 plant design is to provide an advanced, state-of-the-art Human-Machine Interface which is operator friendly and assures error free operation.

## **OPERATOR INTERFACE SYSTEM CONFIGURATION**

The overall CANDU 3 Plant wide Operator Interface System configuration is shown in Figure-1. This is a generic configuration which can be implemented by most commercially available computer systems.

The system architecture is based on a Local Area Network (LAN) with distributed functionality. A dedicated communication module is provided for communication with the F/H distributed control system. Similarly a dedicated F/H Control Console is provided. The main operator interface functions and a central plant-wide database are provided by the dual redundant Plant Display System (PDS) Computers.

## **F/H CONTROL CONSOLE**

The F/H Control Console is located in the Main Control Room (MCR). This provides the primary interface to the F/H operator. The Console consists of 3 CRT's and a set of alphanumeric and function keyboards and a pointing device like a track ball or mouse. All normal and emergency control and monitoring operations can be performed from this console. Each of three CRT's has a primary function assigned to it as given below:

### **Alarm CRT**

The Alarm CRT provides full alarm display and management functions for current and past alarms.

## **Control CRT**

The Control CRT provides the following functions:

1. Automatic supervisory control of F/H operations
2. Manual control of individual drives/devices
3. F/H system start-up and shut-down
4. Calibration of F/H mechanisms

## **Data Display CRT**

The Data Display CRT provides the following functions:

1. F/H system overview information
2. Display of flow sheets
3. Animated displays of F/H operations
4. I/O, drive and equipment data
5. Historical data

Even though each CRT has a primary function, any function can be invoked from any CRT in case of failure of any of the CRT's.

Two printers are also provided at the F/H Operator's work Station. One printer is dedicated for alarms and the other is used for other logging functions.

A portable display terminal is also provided for use in the F/H maintenance room/ rehearsal facility during maintenance and calibration operations.

## **DISPLAY SYSTEM**

User friendliness is a key feature of the F/H display system. Displays are primarily graphic oriented and facilitate operator interactions. Displays are arranged in a logical and hierarchical structure to facilitate ease of navigation through the system to help the operator to obtain correct and timely information. The display system is windows based and is designed on the basis of function analysis. Both information oriented and task oriented displays are provided. The operational status of the F/H system and messages to the operator are shown in simple English text and graphics instead of using mnemonics. The following types of displays are provided at the Operator Work Station:

1. Menu displays
2. Alarm displays
3. Event displays
4. System overview displays
5. Sequential control displays
6. Drive/Device Control displays
7. Process information/flow sheet displays
8. Start-up & Shut-down guidance displays
9. Fuel / Tool inventory displays

10. Mechanism calibration displays
11. Animated F/H operation displays
12. Equipment displays
13. Relevant information displays regarding the reactor & plant

A separate maintenance station is provided for F/H data configuration and display maintenance in the PDS maintenance room. It is proposed to integrate the real time video from the CCTV's into the same CRT's in a separate window. F/H operations procedures are also proposed to be made available on-line to the F/H operator.

In addition a few pages of freely configurable displays are provided. The operator will be able to quickly configure and display specific data required for any non-routine operations without the help of a programmer on these displays.

### **CONTROL OPERATIONS**

The control displays are designed to facilitate full auto, semi-auto and manual control operations for each of the jobs, sequences and drives. The control operations generally involve merely selecting the required operations, commands and set points from menu's in pop-up control windows. The operator is rarely required to input any data or command through the alphanumeric keyboard. Control command validation is carried out before any command is sent to the F/H control system.

### **MANUAL CONTROL PANEL**

All normal, non-routine and emergency control and monitoring operations can be carried out from the F/H Control Console in the Main Control Room. A complete backup manual control panel similar to CANDU 6 is not considered to be necessary as the CANDU 3 Plant Display System is dedicated for Operator Interface functions and is designed for high availability and reliability. However, a stand-up manual control panel is provided with limited control and monitoring functionality only pertaining to the safe state of the F/H system. This panel is used to place the F/H system into a safe state in the unlikely case where the Plant Display System and/or the F/H Control System are not available. The control and monitoring functions on this stand-up panel are configured for direct connection to the F/H drives/devices bypassing the F/H automatic controls.

### **OTHER FEATURES**

The system provides context sensitive on-line help to the F/H operators. System security is implemented through single and multi-level passwords. This prevents unauthorized control operations and also facilitates implementation of supervisory authorizations for certain critical manual operations.

### **APPLICABILITY OF CANDU 3 DESIGN CONCEPT TO OTHER NEW AND EXISTING STATIONS**

The CANDU 3 F/H Operator Interface Design is generic and is directly applicable to new designs like CANDU 9 with minor modifications to accommodate the different F/H system configurations.

This design can also be adapted for retrofits to existing stations. In this case, the control data can be obtained from DCC computers which perform the control functions. Some enhancements to the control software would be necessary to be able to handle full manual control from the F/H Control Console.

## CONCLUSION

The CANDU 3 F/H Operator Interface System design described in this paper provides the following advantages:

1. Enhanced flexibility for operation and maintenance due to the functional independence of the F/H Operator Interface System from the rest of the system.
2. Reduces the amount of manual operations currently being carried out from the manual control panels in the existing stations. This reduces the chances of operator errors.
3. The system is highly user friendly and facilitates easy navigation through the display system to obtain the required data or perform the necessary control functions.
4. The data is presented in a simple and easily understandable form.
5. The system facilitates excellent operator interaction with the F/H system.
6. Fault diagnosis capability is improved.
7. By using the advanced display generation and programming tools, the time required for display system development is considerably reduced.

This also facilitates better software maintenance, quicker display modifications and improvements by the station operating staff.

8. Use of non-proprietary off-the-shelf hardware and software meeting the international standards reduces the risk of obsolescence.
9. Elimination of full back-up control panel and the associated discrete hardware for controls and indications. This results in savings in capital, engineering, construction and site operation costs.
10. Elimination of back-up control hardware and panels results in saving of space in the control room as well as in the control equipment room.

The F/H Operator Interface System developed for CANDU 3 can be adapted to new CANDU designs as well as to the existing stations.

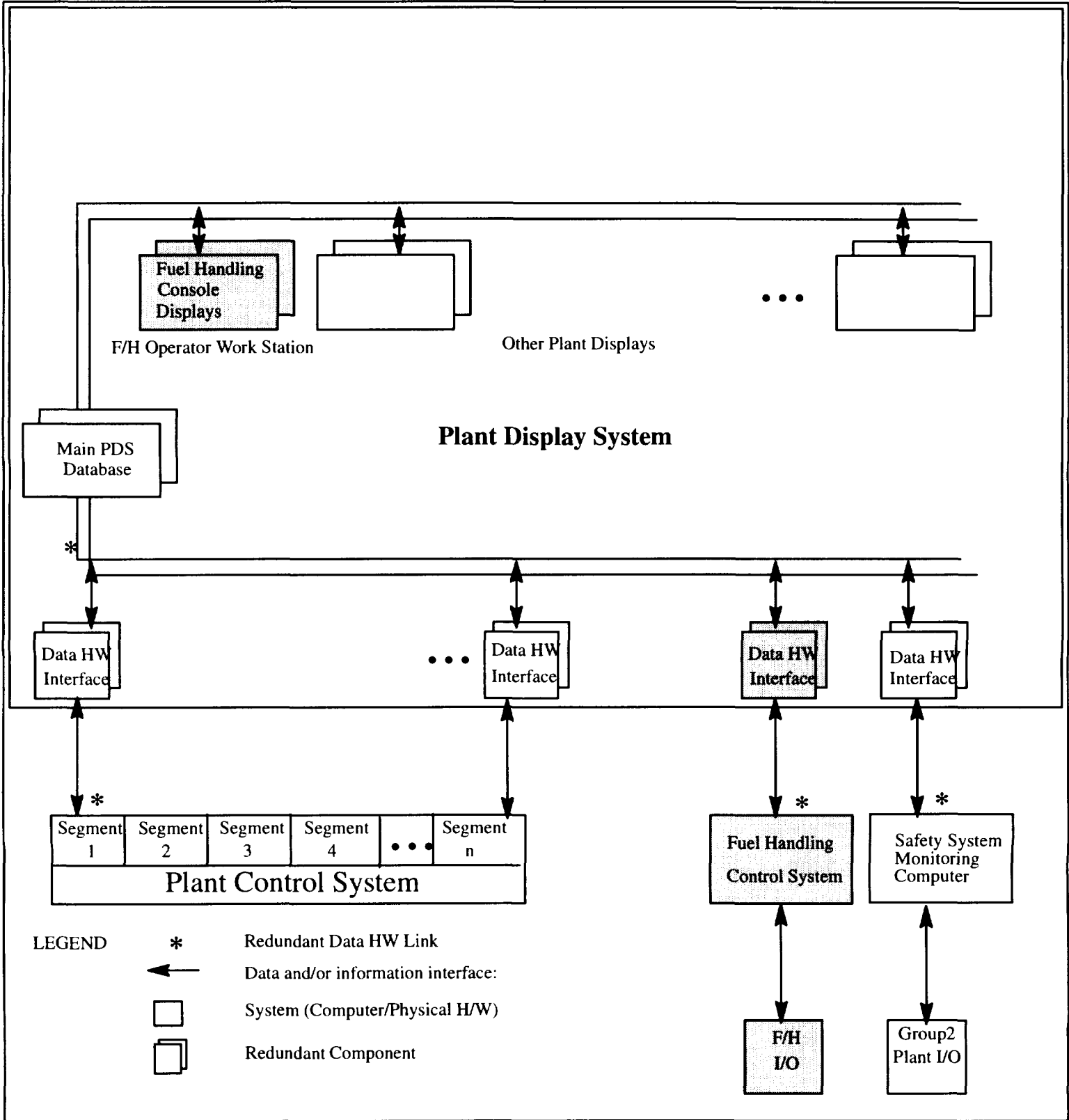


Figure-1  
Plant Display System Configuration