6th International Conference
"Computational Mechanics and Virtual Engineering "
COMEC 2015
15-16 October 2015, Brasov, Romania

CONSIDERATIONS REGARDING THE HORIZONTAL FUEL CHANNELS IN THE CANDU 6 NUCLEAR REACTOR. PART 2 - REFERENCE PLANS OF THE FUEL CHANNEL

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Abstract: *The scope of this study is to identify the reference plans based on which is made the installation into calandria of CANDU 6 nuclear reactor. The design of the CANDU fuel channel is accordingly the result of continuing intensive engineering development of its major components and by ensuring its compliance with the latest Canadian nuclear regulations and the fundamental safety principles of the International Atomic Energy Agency (IAEA) Safety Standards. The fuel channels are assembled and installed into the calandria vessel at the reactor site following installation of the calandria. The fuel channel assembly is made according with the specific requirements of reference planes definition, reference planes measurements, tools and equipments, installation procedures and the quality assurance program. Defining reference plans, measurements reported to reference plans and installation procedures to a new fuel channel in the calandria CANDU nuclear reactor comply the requirements described in the AECL (Atomic Energy of Canada Limited) specified documents.*
Keywords: *Candu reactor, Zirconium alloy, calandria tube, fuel channel, pressure tube, fuel bundle, end fitting, annulus spacer.*

1. GENERAL INTRODUCTION

The nuclear reactors are designed and manufactured with respect of the specific requirements of codes and standards for the manufacture of components, equipment and systems required for the construction and operation of CANDU nuclear power plant.

2. CALANDRIA REFERINCE PLANS

The main aim of the fuel channel in a CANDU reactor is to support and locate the fuel inside of the reactor.
Therefore, the fuel channel integrity must be maintained in all cases of urgency and operating conditions, as all specific security reports provide.
Defining reference plans, measurements reported to reference plans and install operations to a new fuel channel in the calandria CANDU nuclear reactor comply the requirements described in the AECL (Atomic Energy of Canada Limited) specified documents.
Registration documents, check documents and relating reports to the installation of the fuel channel are part of the processes register of the assembly technique reactor.

2.1. Reference plans definition

Defining of Calandria reference plans are carried out between R and R' plans. That is defined as reference planes for front and rear part of the calandria and are illustrated in Figure 1.

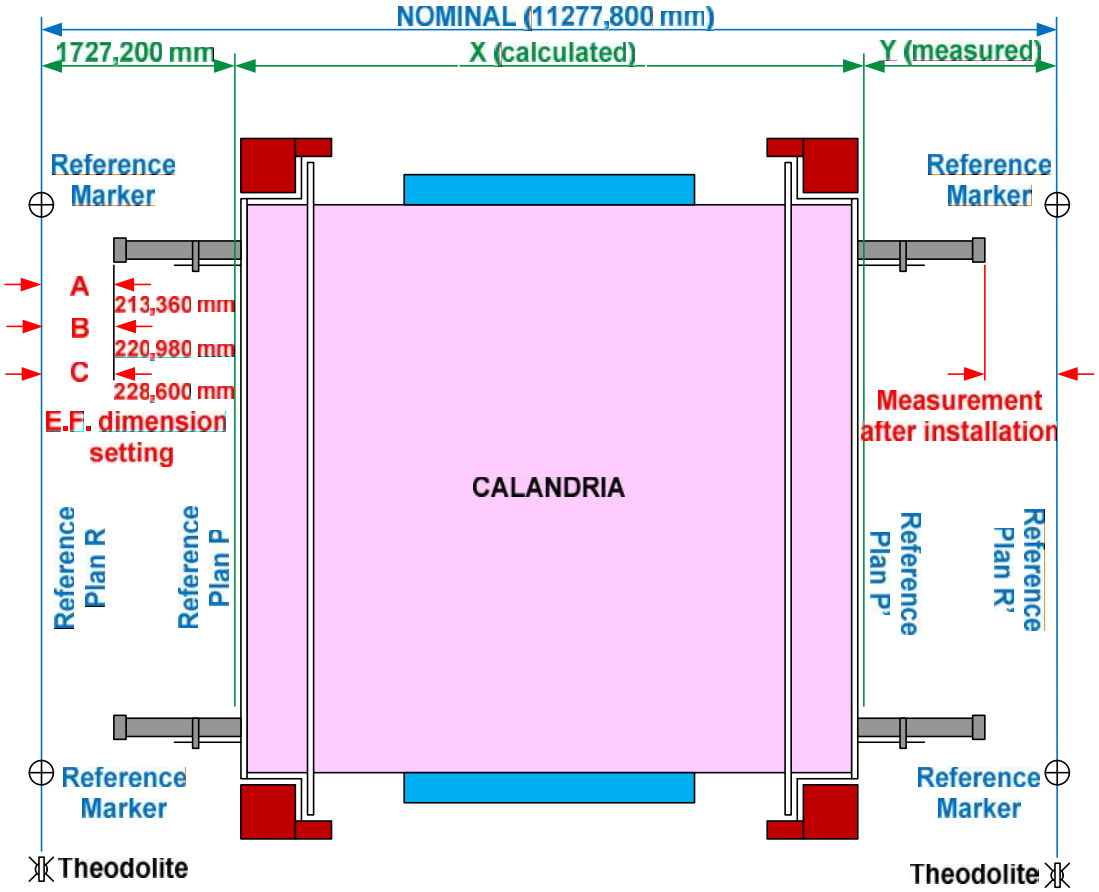

Figure 1: Representation of the reference plans for measurements making at fuel channel installation

The plans determination operations are as follows:
- preliminary determination of the R plan;
- preliminary determination of the R' plan;
- establishing of the R plan reference and markers reference;
- distance determining between P and P' plans reference, front and back calandria plane;
- establishing of the R' plan reference and markers reference.

2.2. The fuel channel measurements reported to the reference plans

The registration document of the reference plans measurements contains entries for:
- used instruments to measurements;
- measured temperatures at different calandria points;
- measurements to the R and to R' reference plan;
- A, B, C and A', B', C' measured distance to the R and to R' calandria reference plans;
- X measured distance between P and P' plan;
- Y measured distance between the P' plan reference and the R' plan reference.

The record document of measurements for fuel channel length calculation provides three fuel channels category:
- A channel category - nominal length of 10,850 mm;
- B channel category - nominal length of 10 836 mm;
- C channel category - nominal length of 10,820 mm;

The recording document of distance measurements from the plan R or R' to end fitting for fuel channel type is prepared to:
- R-A / R'-A' = 213,36 mm;
- R-B / R'-B' = 220,98 mm;
- R-C / R'-C' = 228,60 mm.

The registration document of the fuel channel length calculation for each channel type contains information about channel elements length, shown in table 1.

Table 1: Channel elements length

Channel category	Pressure tube length PT (mm)	Sub-assembly length EF-PT (mm)	Final length of FC (mm)
A	X-1496,57	X+765,61	X+3027,68
B	X-1511,81	X+730,37	X+3012,44
C	X-1527,05	X+735,13	X+2997,20

In the table 1, the notations are as fallow: EF is End Fitting, PT Pressure Tube, FC Fuel Channel and X the measured distance between P and P' plane.
The general registration document for fuel channel installing contains entries for: pressure tube, outer diameter and thickness, end fitting, series no. , color, common bore diameter roller, calculated and final; power feeder angle, calculated and final; gap between pressure tube and the liner tube before and after the rolling phase; the total length of the final sub-assembly; the distance between end fitting and the reference plan before and after rolling; the final overall length of the fuel channel; the data relating to test calibration; the data relating to pressure; welds checking and identifying; identification bulletin control; welder identification.
The general registration document and identification of each fuel channel in report of the calandria aria contains entries for: aria no., the end fitting serial number from R plan, the end fitting serial number from R' plan, the identification code of the pressure tube (see Figure 2).

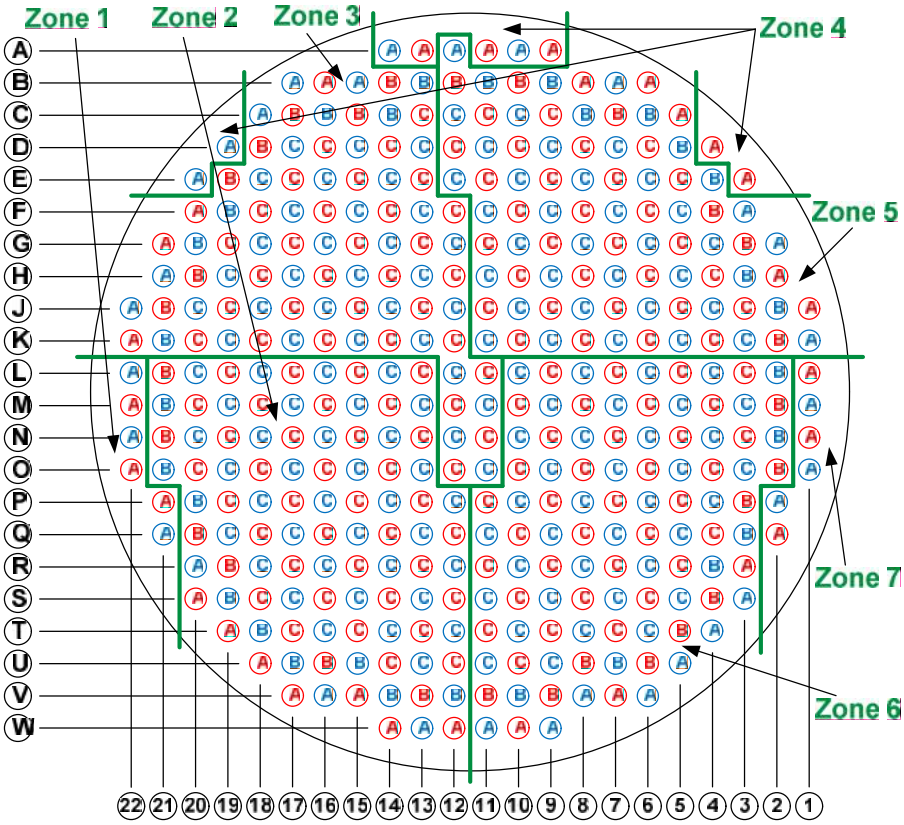

Figure 2: Representation of the cooling zone in relation to end fitting orientation for the feeder pipe connection

The registration document and identification of the mounting position and the end fitting orientation to the end of each fuel channel contains entries for: area no., line, column and front or rear of calandria, input / output feeder type, mounting position of the end fitting at 0°, left 32°, 58°, 90°, 32° right, 58° and 90° (see Figure 3).

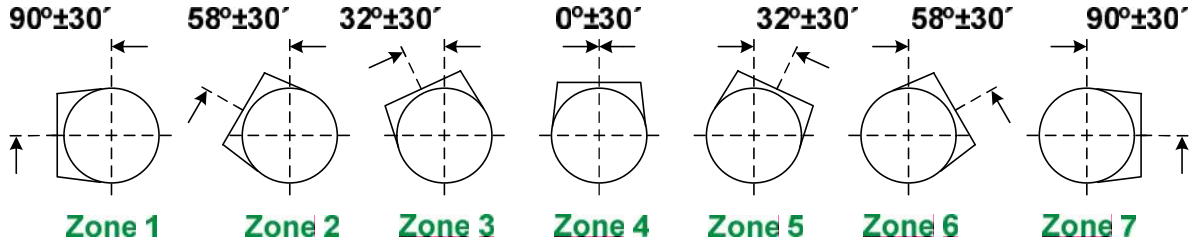

Figure 3: Representation of end fitting orientation for the feeder pipe connection

The registration document and identification of the mounting position of the annulus spacers between pressure tube P/T and calandria tube C/T contains entries for: area no., line, column, the measured distance from the end fitting face, annulus spacer no.1 position, annulus spacer no.2 position, annulus spacer no.3 position, annulus spacer no.4 position (see Fig. 17).

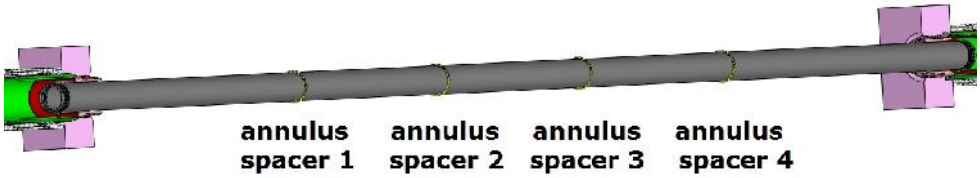

Figure 4: Representation of the annulus spacers position

3. CONCLUSIONS

The design and the configuration characteristics of the fuel channel from the CANDU nuclear reactor are essentially in the design of device components. The fuel channel design has increased margins with extended operating life and is considered a fundamental part in the CANDU system.
The install operations of a new fuel channel in the CANDU nuclear reactor calandria, shall satisfy the requirements described in the documents specified by AECL. The reference plan for a new fuel channel install operations must comply with the described requirements from the specified documents by AECL.
All measurements according to reference procedures are recorded in the reference documents for fuel channel installation.
Documents registration, verification documents and reports of the fuel channel installation will be archived to take anytime a sequential picture of each fuel channel.

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