# DESIGN OF THE CANDU REACTOR ASSEMBLY

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## NOTES FOR LECTURES



### SECTION 1 - Introduction; Overview of the design process; Regulatory requirements, Nuclear design codes and standards

#### 1.1 Introduction

The Lecture Program

This program is comprised of nine main topics given over ten days, covering the process of designing the major component parts of the CANDU reactor system.

The topic, the process of design for the CANDU reactor assembly, could cover a very large amount of information, if it were to include all the wide-ranging technologies, issues and practices involved. This lecture series cannot possibly cover all the processes necessary to produce complete designs for all the major systems making up a reactor assembly. On the other hand, to focus in depth on a narrower set of sub-systems would not present a proper view of the influence the major systems have on one another and on the configuration of the plant itself. Therefore, this lecture series aims to focus initially on these inter-face relationships, and then on the key processes applied in designing the major systems. Some fundamental processes which are applicable to many or all of the systems are reviewed first, to highlight some ways in which the designer's skills and perceptiveness have major influence on the quality of the design produced.

One cannot expect to produce effective, optimal designs by only adapting existing designs, or by simply allowing standardized component design rules and computer modelling to dictate the design. Those items are simply the tools and starting points, which provide guidance and understanding, and the designer must utilize all the information obtained, to produce effective designs. The designer must comprehend the unique aspects of his present situation and the factors which are dominant for it. He must recognize the way in which a new situation has a different balance of the key factors on which a present design was optimized, and he must be prepared to speculate on how new concepts will behave in new situations. This series aims to focus on this aspect.

A good design must first of all meet all its physical and functional requirements, of which cost and reliability are always an important part. In each section of this lecture series, the key aspects of design are discussed from the view-points of both *conceptual* design and *product* design phases. That is, for a *new* reactor design, even though it is usually derived from an existing, proven design, the basic *configuration* and key *parameters* must first be established which relate to the performance requirements for *the new plant*. Furthermore, both these aspects must also reflect requirements or limitations of *inter-facing* systems or equipment. Iterative optimization (and often, compromising) are necessary, and development testing may be required. Once the concepts and key parametric requirements are known, the *design specifications* for the *new reactor design* are firmly established, and the *product design process* begins. In plants which are based on existing standard designs, the design process is almost entirely focused on product design. This lecture series will reflect this approach to the design of practical systems.

Each topic will be addressed in a lecture followed by general discussion or a workshop, requiring participation by the attendees. However, some topics will require more time than others and some flexibility is intended in the presentation. Only nine sessions are structured, and the last session is left open to allow for extension of any topic beyond its nominal period if desired, but it may also be used for supplementary information, general questions and discussion.

The CANDU Reactor Assembly - General Arrangement

The CANDU *reactor assembly* is the system in which the nuclear fission process takes place in *natural uranium oxide* fuel, moderated and cooled by *heavy water*. See schematic **Figure 1-1**. The *fuel bundles* shown in **Figure 1-2** are enclosed and supported in horizontal *pressure tubes* shown on **Figure 1-3**, which are filled with flowing *primary coolant*. The coolant draws off the heat energy produced and transports it to the *steam generators*. Each pressure tube is enclosed within a gas-filled second tube, a *calandria tube*, where the gas is an insulator to minimize parasitic heat loss from the pressure tube. The calandria tubes are surrounded by the *moderator*, which is a separate, low pressure system enclosed in the cylindrical *calandria* vessel. See **Figure 1-4**. Each pressure tube has an *end fitting* at each end with a tee-connection to a *feeder pipe* joining it to the *primary heat transport circuit*. A removable *closure plug* in each end fitting permits insertion and removal of the fuel bundles on power by means of remotely operated *fueling machines*. This sub-assembly is called the *fuel channel*. The calandria vessel ends are closed by double-walled *end shields*, in which the fuel channels are supported. The fission process is monitored and controlled by numerous *reactivity control units* passing vertically and horizontally through the moderator, between the calandria tubes, with electrical connections and drive mechanisms accessibly mounted on the reactor vault exterior. See **Figure 1-5**. The reactor structure is supported on its end shields in the end walls of the reactor vault, and is surrounded by *light water* inside the vault to provide biological shielding. This arrangement permits access to most areas inside the reactor building for on-power maintenance

Main Assemblies and Systems

For design purposes, the overall **reactor assembly** is *comprised* of the following main systems, shown on **Figure 1-5**:

I) the concrete reactor vault, filled with ordinary shield water

ii) the reactor structure assembly (RSA), including the calandria shell (CS), calandria tubes (CT), end shields (ES) and supports

iii) the reactivity mechanisms deck (RMD, comprised of structure and RCU penetrations (not shown)

iv) the fuel channels (FC), including the pressure tubes (PT), end fittings (EF), positioner assembly (PA), closure plugs and other internal items

v) the reactivity control units (RCUs), comprised of neutron & gamma flux sensors, absorbers, actuator mechanisms and connector housings (not shown)

vi) the fuel handling system, (not shown) comprised of the fueling machines, their support & positioning systems, also handling and storage systems for new and irradiated fuel

The reactor assembly *inter-faces* with many major systems, some of which are shown on **Figures 1-6 & 1-7**, as follows: Note that **Figure 1-6** shows the standard generic reference directions A, B, C & D, which have been adopted for CANDUs, (in place of the North, South, East, West compass directions), to provide a reference system which will be common for all sites, regardless of the actual orientation adopted for individual sites.

a) the reactor building lay-out and internal structure design

b) the fuel bundles

c) the fuel management program and the fuel handling control system

d) the primary heat transport system (PHT), including the steam generators, pumps, headers, feeders, pressuriser, and piping

e) the moderator system, including heat exchangers, delay tanks, pumps, and piping

f) the moderator cover gas system, including helium supply tanks, re-combiners, delay tanks, compressors, and piping

g) the shield water system, including heat exchangers, pumps, and piping

h) the reactor regulating system (RRS), including control computers monitoring the RCU fission sensors, the process systems, the turbines & generators and the reactor operator inputs; to generate commands to the RCU absorber actuators

i) the two independent reactor safety shutdown systems (SDS1 & SDS2), each including dedicated circuitry to monitor the nuclear process, the above process systems, the turbines & generators, and reactor operator inputs, to trip the shutdown RCUs

## 1.2 The Design Process

The Design Process is a rational, organized methodology used to obtain an assured, effective resolution to a stated requirement. The process applies equally well to complete plants, systems, machines and the individual components. For a new plant, the process is applied hierarchically, starting with overall plant performance specifications, and repeated for major systems and then for sub-systems and components.

- The key to good design is to identify and respond to *all* of the specific requirements.
- We can identify eight steps in the process, as follows:

1. Compile, Categorize and Quantify the Requirements
2. Assess the Requirements
3. Plan the Program
4. Confirm Understanding of Chosen Concepts - 'Breadboard Testing', Modelling & the Conceptual Design Review
5. Prepare Product Design Specifications
6. Continual Re-assessment and Iteration of the Design in Progress
7. Product Design Verification & Prototype Testing
8. Product Design Review - Confirm that the Requirements are complete, correct and consistent, *and* that the Design *Meets* the Requirements

NOTE that, for a 'standard' plant or item being adopted for a new client, the process is simplified, to focus on the unique aspects of the new plant, and accordingly making updates in step 5 and eliminating steps 4 & 7. However, it is still important to perform the other 6 steps.

### 1.2.1 Discussion of the Steps in the Design Process

1. Compilation of Design Requirements

The importance of having complete, consistent and feasible requirements is stressed. In all cases, the design process *starts* with the careful, complete *definition of the requirement*. This means we must first clearly identify the *main purpose* to be achieved: ie, what job does this entity have to do? Then we must *list* the known or desired *key performance data* which will define the successful solution: ie, speed, pressure, flow, reaction, products, power source, environment, size, weight, cost, construction time, durability, maintainability, etc. The set of requirements has a different focus and composition when applied to plants, major systems, sub-systems, assemblies or components. Requirements may include those from Regulatory bodies, as well as those of established Codes and Standards applicable to a given industry or discipline. Requirements related to interfacing systems may have to be negotiated, both for the influences they have on your system, and vice versa.

Categorization of requirements as *mandatory requirements, design targets and desirable features* is essential, and the latter should be prioritized for their importance. We should also note which requirements and features are merely *"nice to have"* but not essential for success. The *parameters defining requirements* should be *quantified*, with acceptable *tolerances*, to provide a basis for practical design. The assigned priority permits weighting of the relative value of requirements. These requirements will become the *criteria* by which we can finally measure the success of the design, and the level of prioritization for each requirement implies a *"weighting"* to be applied to each item, to provide the overall evaluation.

2. Assessing Requirements

The set of requirements for a given design project must first be assessed to ensure that they are complete, consistent and feasible. Aspects which will likely *dominate* the design or the design process must be identified, either because they are *powerful parametric influences* or because they have significant *uncertainties*. Promising candidate concepts need to be identified and their principal characteristics and features delineated. The primary focus should be on resolving these dominant items, particularly those with significant uncertainties, but viable solutions for *all other* requirements should be defined before proceeding into any detail design work. A specific means of resolving each uncertainty should be identified. The implications of having to adopt alternatives should be considered also. There must be reasonable confidence based on objective reasons that there will be no bad surprises arising at a late stage.

3. Planning the Program

An *overall program plan* can now be prepared which will ensure that all aspects are dealt with in a rational, timely way, and so that all aspects of the design are completed at about the same time. However, at this point the emphasis should be placed on obtaining *verified technical performance*, more than on meeting calendar date targets. It is much better to convince the project manager to provide adequate time and budget at the outset rather than to have ask for delays and increased funding later. On the other hand, including excessive margins to cover all possible problems will result in an excessively long and costly program, and the result may not be any better. The designer must maintain confidence in planning a realistic program with minimal risk, but the confidence must be based on sound judgment.

4. Confirming Understanding of Chosen Concepts - "Breadboard" testing, Modelling and the Conceptual Design Review

A reasonably assured plan of attack should be formulated to resolve each uncertainty *early* in the program, possibly using fundamental research, analysis or testing. Depending on the degree of uncertainty in the concept or in the plan to resolve it, it is prudent to have backup schemes for some risky aspects of the design. If a novel process or device is to be used, it may be necessary to first perform *basic experiments on conceptual models*, either on the computer or on a simple "breadboard" conceptual test rig. This will provide *fundamental* understanding of the basic parametric relationships governing the process or operation. It will provide the basis for calculating initial parametric values to start the design of the actual product, or for planning more specific development tests or studies.

At this stage, the designer will have a fairly clear understanding of his entire design and that it will generally meet its requirements. He will also have a judgment about areas where there may be a risk of a compromise being needed or a shortfall occurring. In most circumstances, a *Conceptual Design Review* should be held. A presentation will be made to a team of peers knowledgeable in his discipline and in related areas. Preliminary documentation will be presented to delineate the design requirements and the designer's assessments of their relative significance. He will describe his design concepts in sufficient detail to demonstrate the design's fundamental completeness and adequacy. He will also declare any uncertainties remaining and the actions he has planned to resolve them; and he will state his assessment of the risks and of the consequences of falling short. The principal purpose of this review is to provide a *documented demonstration* that the requirements being used *are* complete and consistent, and that the planned design *will properly satisfy them*, with a reasonable degree of confidence. The reviewers may also offer critiques of the design itself and may offer suggestions for further investigation or improvement.

5. Preparing Product Design Specifications & Initiating Product Design

Once the basic concepts and configurations are established, the *design specifications* for the sub-systems and component parts can be prepared. The product systems and components are then configured and developed by applying standard engineering formulae and methodology. Geometric arrangements are established in *lay-out drawings;* and manufacturing information provided on *detail drawings* or *component specifications*. These will include materials, heat treatments, finishes, fits and tolerances for manufactured items, and geometric and performance requirements for proprietary items. Documentation must be produced, including Design Descriptions, Manufacturing Specifications, Acceptance Performance Test

Specifications, Installation & Commissioning Requirements, and Operation & Maintenance Manuals.

During this time, the design of the *components parts and processes can be validated and tested*, either by analysis or physical experiments, and details revised until each part or sub-system meets its specifications.

Quality Assurance measures are applied to the design output to *ensure that all items are complete and consistent with each other and with the design objectives*, and that they conform to company or industry standards. Each drawing and specification is reviewed and checked. Similarly, each manufactured part and assembly is inspected to ensure it conforms to the specifications and drawings.

Documentation covering design, analysis & test programs, and QA processes typical of AECL's CANDU programs will be reviewed.

6. Continual Re-assessment and Iteration of the Design in Progress

Throughout the execution of the design and at each stage in the process, the *result* achieved for a given item or sub-system should be *compared to its requirements*, and the *influence of that result on the overall design should be assessed*. It may become necessary for the designer to adjust the component part requirements in order to effect different compromises, so as to obtain the optimal overall design. It also may be necessary to negotiate with the designers of interfacing systems to change the requirements imposed by their systems, or to change the requirements placed on them by your system. This *iterative process* is the key to achieving an *optimum design*. Caution must be exercised, however, to maintain a proper balance on prolonging the design process and increasing cost, for marginal gain. In most cases, the designer should use his judgment to stop making improvements, and complete the design.

7. Product Design Verification and Prototype Testing

Finally, the *prototype or "first off"* of the entire design is assembled and subjected to *performance testing*, under actual or simulated conditions. If reliable computer modelling has been developed for each component part and for their interactions in the overall unit, this "prototype" may be a computer model, and it will be subjected to simulation or analysis. In most circumstances, a system will be proven by a combination of these methods.

All output performance parameters are measured and the degree to which the design meets *all* its weighted requirements is the measure of its actual overall performance. It may be necessary to further adjust the compromises between sub-systems and sub-assemblies, and to iterate the process for the entire design, to obtain the desired optimization.

These analyses and tests must be precisely specified and controlled, to ensure they are properly representative of the design and all the conditions to be applied. For each significant aspect of the design to be analysed or tested, a consistent set of documents is required. First, they must completely define the configuration and parameters of the item to be checked, and the conditions to be applied to it; they must include the methodology of application or analysis and the assumptions being included. If physical tests are applied, the test rig and instrumentation must be defined. This "input" document is a Test Specification or Analysis Basis Specification, and it should be reviewed and verified by the designer prior to testing or analysis. Second, the "output" from the verification program, the Test Report or Analysis Report, must provide the complete set of final data obtained, with notation about actual conditions, limitations, and failures found.

Typical candidate situations for test and analysis verifications will be identified in the example designs, and Test or Analysis Specifications shown.

## 8. Product Design Review - Confirming the Design Meets the Requirements

To complete the design process, it is essential to *compare the performance of the finished design to the requirements* established at the beginning. The design can be declared a success if it meets all its *mandatory* requirements *and* attains reasonable values for all of its *design target* parameters. Often, in complex systems, the degree of success may be judgmental, depending on the relative importance the reviewer places on eventual compromises reached. In this regard, producing superior performance does not necessarily produce a superior design, if doing so has caused a shortfall in some other key aspect; eg, superior output or strength is not beneficial if the cost or weight targets are significantly exceeded.

The design program is formally completed by holding a *Design Review*. This will be a more formal review meeting than the preliminary review held earlier. Final Design Requirements, Design Descriptions and drawings are issued prior to the meeting, along with key Specifications and Reports for Verification Analyses and Tests. Reviewers will study these documents closely, to confirm that the requirements remain complete, consistent and correct at this stage of the program, including the parts of the documents relevant to interfacing systems. They will then ensure that the reports provided *do* verify full compliance with those requirements. The designer will be asked to clarify any uncertain aspects raised by the reviewers. A report is usually issued on the review, and items considered incomplete or unsatisfactory are identified, and the review is not considered completed until all such questions have been satisfactorily dealt with.

## 1.3 Regulatory Requirements and Design Codes and Standards

- CANDU reactors are designed and constructed to meet Canadian government requirements and standards for safety, reliability, and economic production of power. In general, they encompass internationally recognized IAEA and ASME practices wherever applicable, or meet the same intent while addressing the unique aspects of the CANDU concept and Canadian practices.

- The *federal* regulatory agency, the **Atomic Energy Control Board, (AECB)** is the agency responsible for licensing of design, qualification and operation of all *nuclear* facilities in Canada. It issues broad guidelines governing safety standards and criteria for plants, and reviews and approves owner submissions covering those aspects of plant design.

    - The key AECB guideline documents are outlined in **Table 1-1.**

- Each *provincial* **Department of Labour (DOL)** holds responsibility for approval of design, construction and operation of *pressure retaining systems*. (In Ontario, it is called the Ministry of Corporate and Consumer Relations (MCCR)). They define the standards to be used and provide reviewers and inspectors to ensure compliance.

    - All the provincial agencies have adopted the **Canadian Standards Association** standard CSA N285.0 and related standards it designates, for *pressure retaining systems* for CANDU power reactors.

- The CSA N285.0 standard requires that designs for all pressure retaining items must be *registered with the provincial jurisdiction* (ie, with the DOL or MCCR). It designates the parties responsible for each phase of the work to design, build and operate a plant. The CSA N285 series, and the related standards it designates, define all the rules for design, analysis, manufacture, inspection & test. In fact, the CSA standards *directly* define rules for *unique* CANDU *requirements*, and otherwise specify *applicable parts* of the ASME Boiler & Pressure Vessel Code. The CSA B51 standard is also referred to, for systems which contain virtually no active materials.

  The CSA N285.0 standard is outlined and further described in **paragraph 1.3.1,** below. The steps to be followed in the process of designing of a nuclear pressure retaining system, vessel or section of piping will be will be seen in this outline. Other documents, codes and standards related to and referenced by CSA N285.0 are outlined in **paragraph 1.3.2.**

- The ASME Boiler and Pressure Vessel Code gives specific *rules for design, documentation, manufacture and inspection for pressure retaining items.* Its Section III covers design, manufacture and operation, including acceptable standard configurations, permitted rules and methods for stress analysis, and allowable stresses for qualified materials. It also defines categories of normal, abnormal and emergency service conditions, and levels of allowable stresses permitted for each. Section IX covers welding, including qualification of weld processes and the welders applying them. Section XI covers In-service Inspection.

- The CSA N286 series of documents specify requirements and processes for assuring proper *quality* is maintained *throughout the design, manufacturing, construction and operating phases*. Basically, they require that a listing is prepared at the outset, of all the steps which must be performed to complete a given design or manufacturing process, including analyses, tests, reviews and documentation. They also require that the set of tasks be verified to be complete, and that a particular designer or vendor is designated to be responsible for each task, and that he knows this and is properly qualified to perform the task.

- The CSA Z299 series of documents specifying organizational responsibilities, procedures and standard methodologies for *ensuring quality* assurance in the *manufacturing and construction* processes. This series is presently being superseded by the universal ISO 9000 series of standards.

### 1.3.1 Outline of CSA N285.0

#### 1.3.1.1 BACKGROUND TO PRESENT (-95) REVISION

The first issue of CSA N285.0 was M81, issued in 1981 and amended in 1987.

Its **basic purpose** is to:

- *standardise* the way we classify, register and control pressure retaining system design *in Canada*,

- regulate *unique design aspects of CANDU* which ASME doesn't cover.

The next version was CAN/CSA N285 M91, issued in July, 1991, to reflect 10 years of experience. It also changed the rules for system *code classification*.

The present -95 version was issued May, 1995 and is a further update and includes fairly extensive revision in many respects to reflect the way we presently proceed.

#### 1.3.1.2 SPECIFIC OBJECTIVES OF CAN/CSA N285.0 STANDARD

(1) It defines the AUTHORITIES AND RESPONSIBILITIES for

. design, registration, construction and operation
. for pressure retaining equipment
. in nuclear power plants
. in Canada.

The **AECB** is the *federal regulatory body* which *licences reactors*

**MCCR & DOLs** are the *provincial departments* which enforce *provincial Pressure Vessel Acts* and register designs. (Registration is NOT done in USA):

eg: RESPONSIBILITIES

| | | |
|---|---|---|
| ***OH, NBP, KEPCO, CNNC etc*** | are **owners** | have *overall* responsibility for design, construction & operation and for establishing quality assurance, but *delegate* responsibilities to: |
| ***OH, AECL, NPM*** | as **architect/engineers** | do *plant* design & specify systems |
| ***OH, AECL, GEC, etc*** | as **system designers** | do *system* design & specify piping and components |
| ***AECL, GEC, Parsons, Babcock-Wilcox, etc*** | as **item designers** | do piping/ component design and specify manufacture and construction |
| ***OH, NBP, KEPCO, equipment suppliers,*** | as **suppliers/installers** | do fabrication, installation & equipment commissioning |

(2) It gives Canadian rules for *classification* to suit the Canadian *safety philosophy*.

(3) It gives *rules* for design, materials, fabrication and installation:

. when to use *CSA N285.2 or .3* for *unique CANDU* aspects, and

. when to use *ASME rules*

(4) It gives rules for *periodic inspection* to meet Canadian requirements *(CSA N285.4 & .5)*

(5) It specifies unique CANDU *materials (N285.6)*

1.3.1.3 SUMMARY OF CSA N285.0-95

Clause 1 - Defines scope of this standard.

Clause 2 - Lists referenced and associated standards and codes; lists definitions.

Clause 3 - Overviews general requirements; effective dates.

Clause 4 - Defines Responsibilities.

Clause 5 - Rules for classification: process systems; safety systems; containment items; emergency shutdown and cooling systems; supports; instruments.

Clause 6 - Rules for registration: categorization as: systems; vessels; supports; pumps; fittings; welding.

Clause 7 - Rules for design: classes 1, 2 & 3 referred to ASME; classes 1C, 2C & 3C referred to CSA N285.2; class 4 (containment) referred to CSA N285.3; class 6 referred to CSA B51; seismic requirement; overpressure protection; documents required, contents & certification; flowsheets. Also defines loading conditions and combinations of conditions to be used for design, ie, Levels A through D Service Loadings.

Clause 8 - Materials: referred to ASME Sec III, Div 1, sub-sections NB 2000, NC 2000 or ND 2000 for standard materials; or CSA N 285.6 (or N285.3) for unique CANDU materials.

Clause 9 - Fabrication & Installation: referred to ASME Sec III, Div 1, NB 4000, NC 4000 or ND 4000; or CSA N285.2 & N285.3.

Clause 10 - Quality Assurance: defines required standards and systems for all stages from design and analysis through manufacture, installation, operation and maintenance; referred to CSA N 286.0 (overall program), N286.1 (procurement), N286.2 (design), and N286.3

& N286.4 (installation & commissioning). Manufacturing and Supply refer to CSA Z299 series, now being replaced by ISO 9000 series.

Clause 11 - Inspection, Examination and Testing: specifies acceptable methodology, equipment, personnel qualifications, records.

Clause 12 - Records, Identification and Reports

Clause 13 - In-service requirements

Clause 14 - Supports

Table 1: Summary of documentation required for each type and class of item

Table 2: Summary of records required for manufactured items

Figures 1 through 18: samples of standard documents and forms

Appendix A: Outline of contents required for piping systems' documents

### 1.3.1.4 CHANGES BETWEEN ISSUE CSA N285.0-M81 to -M91

Note that M81 version is still in heavy use for operation, repair or refurbishment to operating plants; therefore we should first look at the change from M81 to M91:

1) M91 changes:

- Sections of size 3/4 NPS or smaller now classified as Class 6, regardless of the main system's class; and designed and registered to CSA standard *B51* (non-nuclear pressure systems)

- Rules for classification changed (Clause 5):

[NOTE: Code class defines which set of design rules are to be used for that item]:

- Class 1 **was**: (I) PHT system and specified special safety systems,
(ii) any system which, if it has a LOCA, would permit a release exceeding the AECB-allowed dose limit into containment

**became**: any system which *directly cools fuel* and could have LOCA

- Class 2 **was**: its release dose won't exceed AECB limits, but it is not class 1 (ie the fluid is active but it does not contain fuel)

**became**: *penetrates containment*, regardless of its fluid conditions,

-Class 3 **was**: any system which contains active fluid, but not at Class 2 level

**became**: any system which contains *low-activity fluid*, above a specified activity level (10 Ci/kgm).

- Class Special

**was**: any unique CANDU item which didn't conform to ASME design rules

**replaced by**: **Class 1C, 2C, 3C**; *a new concept:*
- denotes that item's *class* is defined normally, but that special *CANDU design rules* have to be used, as specified in CSA standard *N285.2*

- Class 6: (I) radio-activity content *criterion* added:
(ii) sections 3/4 NPS size included, *regardless of class of main system* it is part of
(iii) design *and register* it to rules of CSA B51

- Rules for Design inadvertently omitted (Clause 7.2, .3, .4): ie, was *supposed* to say when to use ASME and when to use CSA N285.1, .2, B51, etc.

### 1.3.1.5 **NEW CHANGES: M91 to -95**

- General: There has been a very *extensive text revision* throughout, both to clarify *wording and to update requirements to reflect the way we actually do business*. Clauses 4 (responsibilities), 5 (classification), 6 (registration) and 7 (design), also Tables 1 and 2; many of the standard forms (figures) have been updated.

- The entire standard N285.1 has now been withdrawn, since it primarily only directed the designer to use ASME rules for items in *normal* class 1, 2 or 3, ie, those *not* having unique CANDU considerations. A few necessary special CANDU aspects previously noted in N285.1 (mostly administrative) are now included within N285.0 text.

- Clause 4, Responsibilities now recognises that, in the process of design, responsibilities have to be undertaken hierarchically, but it does not specify a particular organization, group or individual as carrying the responsibility. It recognises this may vary, depending on project or corporate organization.

It requires only that a higher level authority prepares the requirement for, and subsequent review of the work done by a subordinate level. The plant owner holds ultimate responsibility but usually delegates the plant, system, and item design processes, and manufacturing, installation and test.

- Clause 7, Rules for Design restored. Clause was also revised to accommodate deletion of standard N285.1, and to direct designer directly to ASME rules for standard items which do not have unique CANDU features requiring special rules.

1.3.2 Other standards and codes related to/ or referenced by CSA N285

CSA B51-95 - Boiler, Pressure Vessel, and Piping Code. Covers non-nuclear pressure retaining systems and items.

ISO 90001 - QA for Design, Development, Production, Installation and Servicing

ISO 90002 - QA for Production, Installation and Servicing

ISO 90003 - QA for Final Inspection & Test

CSA N285.2 M89 - Requirements for Class 1C, 2C, & 3C Pressure-Retaining Components and Supports in CANDU Nuclear Power Plants

CSA N285.3-88-(R94) - Requirements for Containment System Components in CANDU Nuclear Power Plants

CSA N285.4-94 - Periodic Inspection of CANDU Nuclear Power Plant Components

CSA N285.5 M90 - Periodic Inspection of CANDU Nuclear Power Plant Containment Components

CSA N285.6 - Series 88 (R94) - Material Standards for Reactor Components for CANDU Nuclear Power Plants

CSA N286.0-92 - Overall Quality Assurance Program Requirements for Nuclear Power Plants

CSA N286.1-84 (R94) - Procurement Quality Assurance for Nuclear Power Plants

CSA N286.2-86 (R94) - Design Quality Assurance for Nuclear Power Plants

CSA N286.3-83 (R94) - Construction Quality Assurance for Nuclear Power Plants

CSA N286.4-M86 (R94) - Commissioning Quality Assurance for Nuclear Power Plants

CSA N287.1-93 - General Requirements for Concrete Containment Structures for CANDU Nuclear Power Plants

CSA N289.1-80 (R92) - General Requirements for Seismic Qualification for CANDU Nuclear Power Plants

CSA N289.3-M81 (R92) - Design Procedures for Seismic Qualification for CANDU Nuclear Power Plants