AFCEN RCC-CW Errata 001 - EN

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NOTE TO THE USERS

This document proposes modification which correspond to a change in symbols used to describe actions due to pool water temperature variations in accordance with DGENR.

The following pages are to be replaced:

RCC-CW 2021 English version		
Chapter	Section	Page
GDEFN	GDEFN 4200	5/12
DCONC	DCONC 1100	1/48
DCONC	Table DCONC 2110-1	5/48
DCONC	Table DCONC 9000-1	44/48
DPLIN	DPLIN 5000	3/10 & 4/10
RCC-CW 2023 English version		
Chapter	Section	Page
GDEFN	GDEFN 4200	5/12
DCONC	DCONC 1100	1/48
DCONC	Table DCONC 2110-1	5/48
DCONC	Table DCONC 9000-1	44/48
DPLIN	DPLIN 5000	4/12

RCC-CW

Rules for Design and Construction of PWR Nuclear Civil Works

EDITION 2021

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GDEFN 4200 VARIABLE ACTIONS

Symbol	Action
Q	Variable action.
Q_k	Characteristic value of a variable action.
$Q_{k,C}$	Characteristic value of variable action applied during construction.
$Q_{k,E}$	Nominal value of action due to DBSE.
$Q_{k,L}$	Characteristic value of the variable actions applied during operation (including reactor shutdown).
$Q_{k,s}$	Nominal value of action due to snow.
$Q_{k,T}$	Characteristic value of effects due to temperature variations of ambient air from its mean value during normal operating conditions.
$Q_{T,p,m}$	~~Maximal pools thermal value.~~ Characteristic pools thermal value determined with maximum thermal value during operation, including incidental occurrence.
$Q_{T,p,f}$	~~Frequent pools thermal value.~~ Characteristic value of effects due to temperature variations of water in pools during normal operating conditions.
$Q_{k,test}$	Characteristic value of the variable actions applied during test conditions or when applying test pressure.
$Q_{k,w}$	Characteristic value of action due to wind.
$Q_{k,wl,EF}$	Characteristic value of effects due to the variations of level of the groundwater table considered as “frequent level”.
$Q_{k,wl,EH}$	Characteristic value of effects due to the variations of level of the groundwater table considered as “high level”.

DCONC GENERAL RULES FOR CONCRETE STRUCTURES

Unless otherwise specified in the following paragraphs, the basic principle is that the EN 1992-1-1 requirements with the recommended values shall be used to design reinforced and/or prestressed concrete structures.

The following status for the annexes of EN 1992-1-1 shall apply:

Tables DCONC-1: status of EN 1992-1-1 annexes

Annex		Status
A	Modification of Partial Factors for Materials	Non Applicable
B	Creep and Shrinkage Strain	Non Applicable
C	Properties of Reinforcement Suitable for Use with this Eurocode	Normative
D	Detailed Calculation Method for Prestressing Steel Relaxation Losses	Informative
E	Indicative Strength Classes for Durability	Informative
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H	Global Second Order Effects in Structures	Informative
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NOTE The titles provided in the Table refer to the actual titles of annexes and not to the titles as provided in the contents list of EN 1992-1-1.

The chapter presents the requirements for concrete structures. Specific requirements and values applicable to RB containment are given in DCONC 5000. They supersede other requirements given in DCONC.

DCONC 1000 GENERALITIES

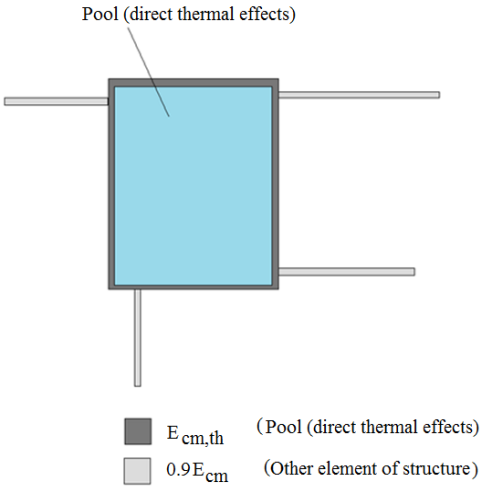
The actions considered in design are defined in DGENR and DGEOT and are supplemented by the following requirements.

DCONC 1100 THERMAL EFFECTS

Three types of actions relating to temperature shall be considered:

- permanent thermal action ($G_{k,T}$, see DGENR 3310);
- variable thermal actions ($Q_{k,T}$, $Q_{T,p,f}$ ~~$Q_{k,T,N}$~~, and $Q_{T,p,m}$ ~~$Q_{N,T,E}$~~ see DGENR 3320);
- accidental thermal actions ($A_{db,T}$, see DGENR 3330).

Table DCONC 2110-1: modulus of elasticity of concrete

Studied effects	Value of E_c	Explanation
Short-term mechanical effects	$E_c = E_{cm}$	E_{cm} is the secant modulus of elasticity as defined in EN 1992-1-1, 3.1.3
Long-term mechanical effects	$E_c = E_{c,eff} = \frac{E_{cm}}{1 + \varphi_b(t,t_0)}$	$E_{c,eff}$ is the effective modulus of elasticity as defined in EN 1992-1-1, 7.4.3, (5), with: - $\varphi_b(t,t_0)$ is the creep coefficient defined in APPENDIX DB (based on EN 1992-2, Appendix B); - t is the design working lifetime ($t = t_f$), and; - t_0 is the age of concrete at the time of loading.
Thermal effects related to exceptional or accidental situation on pool or on the RB containment: $Q_{T,p,m}$ ~~$Q_{N,T,E}$~~, $A_{db,T}$, $A_{de,P}$, $A_{de,St}$, $A_{db,P}$, $A_{de,A}$, $A_{db,S}$ (short term)	$E_c = E_{cm,th} = \frac{E_{cm} + 2E_{c,eff}}{3}$ $E_c = 0.9 \cdot E_{cm}$	$E_{cm,th}$ shall be used for elements directly in contact with water and $0.9 \cdot E_{cm}$ shall be used for other elements indirectly impacted by thermal load. The reduction factor defined in DCONC 4200 is applicable for all elements. Example of used modulus: 
Thermal effects related to variable action $Q_{k,T}$ (long term)	$E_c = \frac{E_{cm} + E_{c,eff}}{2}$	
Thermal effects related to variable action $Q_{T,p,f}$ ~~$Q_{k,T,N}$~~	$E_c = E_{c,eff}$	
Thermal effects related to climatic accidental action $A_{db,T,ext}$	$\boldsymbol{E_c = \frac{E_{cm} + E_{c,eff}}{2}}$	

(3) Shrinkage and creep

The formulae provided in APPENDIX DB shall be used for shrinkage and creep calculations.

Exothermic effects during early hydration and autogenous shrinkage are not added to drying shrinkage. It shall be verified that the reinforcement designed for other loads can resist the imposed tension stresses.

The effects of shrinkage shall only be taken into account for SLS, not for ULS, as defined in EN 1992-1-1, 2.3.2.2.

Table DCONC 9000-1:
specific material criteria for walls and slabs of the spent fuel pool

		Normal operating (2eL SLS.qp)	Normal operating (2gt SLS.f)	~~Exceptional~~ Maximal water temperature (2h SLS.c)	Accidental water temperature (7 ULS.a)
Concrete	Compression stress σ_c [MPa]	$Max\ \sigma_C \le 0.6 \cdot \frac{f_{ck}}{\gamma_c}$ $Mean\ \sigma_C \le 0.45 \cdot \frac{f_{ck}}{\gamma_c}$	$Max\ \sigma_C \le 0.6 \cdot \frac{f_{ck}}{\gamma_c}$ $Mean\ \sigma_C \le 0.45 \cdot \frac{f_{ck}}{\gamma_c}$	$Max \sigma_C \le 0.6 \cdot \frac{f_{ck}}{\gamma_c}$	
	Compression stress in shear strut σ_{cw} [MPa]				$Max\ \sigma_{cw} \le \frac{f_{ck}}{\gamma_c}$
Passive reinforcement	Tensile stress σ_S [MPa]	$\sigma_{s,max} \le \min\left\{\frac{2}{3} \cdot f_{ys}; \max\left(0.5 \cdot f_{ys}; 110 \cdot \sqrt{\eta \cdot f_{ctm}}\right)\right\}$ with $f_{ys} = \min(f_{yk}$; 500 MPa) and $\eta = 1.6$ for high-bond reinforcements		$Max \sigma_S \le 0.8 \cdot \frac{f_{yk}}{\gamma_S}$	
	Ultimate strain ε_{uk} [‰]				10‰.(see DCONC 2120)

For walls and slabs of pools with metallic liner, the environmental exposure classes shall be specified by the Project in accordance with local specific conditions, in particular potential aggressiveness of the liquids or potential chemical attacks (pH,…).

For pool elements containing boric water, the following should apply:

- Minimum environmental exposure class XA1;
- Concrete cover $C_{min,dur} \ge 45$mm.

The design environmental exposure class and the concrete cover shall be submitted to the Project approval.

DCONC 10000 ADDITIONAL RULES FOR THE DESIGN OF THE AIRPLANE RESISTANT SHELL

This section describes the civil engineering requirements to demonstrate the stability and the load-bearing capacity of structural components in case of an aircraft crash.

Checks of the local zone of impact and the building as a whole shall be carried out. APPENDIX DC provides an acceptable method to check impact effects according to load diagram defined in a specific document, such as SR.

The purpose of the overall analysis is to identify movement at different points of structures and calculate the internal forces in structural elements not directly affected by the impact. The zone of impact and its immediate vicinity are generally represented separately from the overall model.

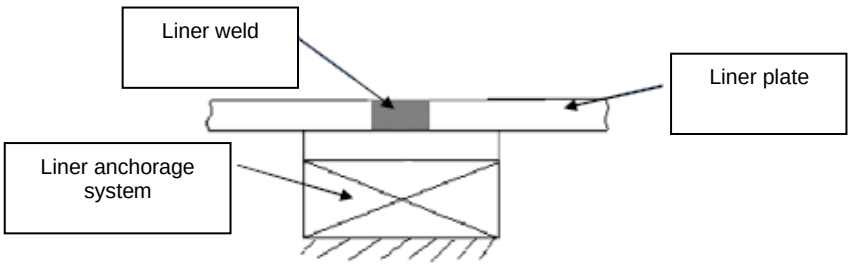


Figure DPLIN 4000-2: Pool Design 2 – Design principle sketch

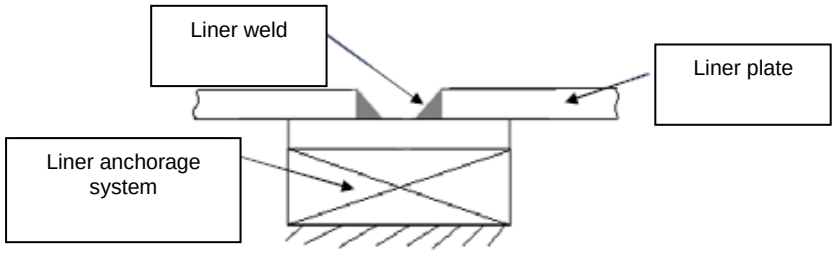


Figure DPLIN 4000-3: Pool Design 3 – Design principle sketch

In all cases, the design shall take into account the constraints related to required controls for welds (See CPLIN).

DPLIN 5000 COMBINATIONS OF ACTIONS TO BE TAKEN INTO ACCOUNT

The main combinations of actions to be considered are taken from Table DGENR 3400-1 and Table DGENR 3400-2, with all load factors taken as 1.0. Only actions affecting the metal parts are taken into account.

In these combinations, two categories of actions shall be considered:

- the actions applied by the concrete to the liner (due to prestressing, creep, shrinkage, earthquake, etc.), which are expressed only in terms of strains or displacements;
- the actions which are directly applied to the liner (hydrostatic pressure due to liquid concrete during construction, self-weight, internal pressure, temperature, etc.) expressed in terms of stresses or strains.

Combinations of actions are classified into following levels:

Level 0:

Construction:

(1) $(G_{k,sup}\ ;\ G_{k,inf})^* + Q_{k,C} + Q_{k,T} + Q_{k,w} + Q_{k,s}$

Level I.1:

Normal operation:

(2) $(G_{k,sup}\ ;\ G_{k,inf})^* + Q_{k,L} + Q_{k,T} + Q_{T,p,f}$ ~~$Q_{k,T,N}$~~

Design Basis Serviceability Earthquake (DBSE):

(4) $(G_{k,sup}\ ;\ G_{k,inf})^* + Q_{k,L} + Q_{k,T} + Q_{k,E}$

Level I.1 bis:

~~Exceptional~~ Maximal water temperature:

(2h) $(G_{k,sup}\ ;\ G_{k,inf})^* + Q_{k,L} + Q_{k,T} + Q_{T,p,m}$ ~~$Q_{N,T,E}$~~

Level I.2:

Design Basis Earthquake (DBE):

(11) $(G_{k,sup}\ ;\ G_{k,inf})^* + Q_{k,L} + Q_{T,p,f}$ ~~$Q_{k,T,N}$~~ $+ A_{db,E}$

Aircraft crash:

(12) $(G_{k,sup}\ ;\ G_{k,inf})^* + Q_{k,L} + Q_{T,p,f}$ ~~$Q_{k,T,N}$~~ $+ A_{db,apc}$

Level I.2 bis :

Accidental water temperature:

(7) $(G_{k,sup}\ ;\ G_{k,inf})^* + Q_{k,L} + A_{db,T}$

Level II.1:

Severe Accident (SA / DEC B):

(DE1c) $(G_{k,sup}\ ;\ G_{k,inf})^* + Q_{k,L} + A_{de,A}$

Severe Accident and φ Design Basis Earthquake (SA / DEC B + φ DBE):

(DE1d) $(G_{k,sup}\ ;\ G_{k,inf})^* + Q_{k,L} + \varphi A_{db,E} + A_{de,A}$

Level II.2:

Design Extension Earthquake (DEE):

(DE3) $(G_{k,sup}\ ;\ G_{k,inf})^* + Q_{k,L} + Q_{k,T} + A_{de,E}$

(*): The critical case between $G_{k,sup}$ or $G_{k,inf}$ shall be chosen.

DPLIN 6000 LINER DESIGN RULES FOR TYPE PD1 OR PD2

DPLIN 6100 PRELIMINARY RULE TO DETERMINE THE SPACING OF ANCHORS

This preliminary rule shall be used only for the design type PD2.

Buckling of the metal plate shall be studied according with DCLIN 3350 (elastoplastic analysis) to determine the position of the anchors and thus achieve a first layout drawing of the liner. To perform this analysis, the initial shape defect is a blistering of the metal plate which shape corresponds to the first mode of buckling with realistic amplitude (based on the flatness tolerances).

Notations:

- θ = temperature;
- $\varepsilon_L = \varepsilon_L(\theta)$ = minimum value of ultimate elongation in pure tension of the material according to the temperature θ.

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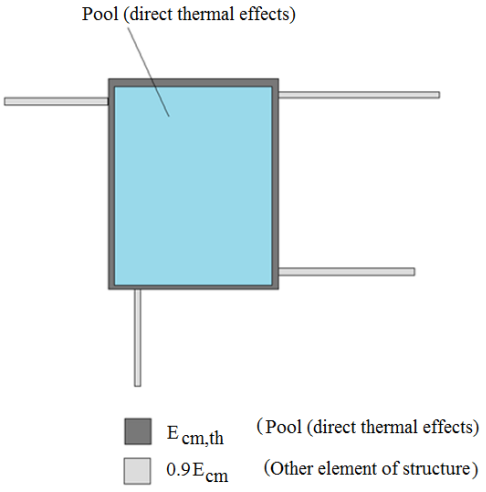
Thermal effects related to exceptional or accidental situation on pool or on the RB containment: ~~$Q_{N,T,E}$~~ $Q_{T,p,m}$, $A_{db,T}$, $A_{de,P}$, $A_{de,St}$, $A_{db,P}$, $A_{de,A}$, $A_{db,S}$ (short term)	$E_c = E_{cm,th} = \frac{E_{cm} + 2E_{c,eff}}{3}$ $E_c = 0.9 \cdot E_{cm}$	$E_{cm,th}$ shall be used for elements directly in contact with water and $0.9 \cdot E_{cm}$ shall be used for other elements indirectly impacted by thermal load. The reduction factor defined in DCONC 4200 is applicable for all elements. Example of used modulus: 
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Level I.2:

Design Basis Earthquake (DBE):

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Aircraft crash:

(12) $(G_{k,sup}\ ;\ G_{k,inf})^* + Q_{k,L} + Q_{T,p,f}$ ~~$Q_{k,T,N}$~~ $+ A_{db,apc}$

Level I.2 bis :

Accidental water temperature:

(7) $(G_{k,sup}\ ;\ G_{k,inf})^* + Q_{k,L} + A_{db,T}$

Level II.1:

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