NATIONAL REPORT OF CHILE

"JOINT CONVENTION"

ON THE SAFETY OF SPENT FUEL MANAGEMENT AND ON THE SAFETY OF RADIOACTIVE WASTE MANAGEMENT.

October, 2017

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SECTION A – INTRODUCTION

A.1 Introduction

This national report describes the activities made by Chile related to the safety of radioactive waste management (RW) and safety of the spent fuel management (SF).

The report is prepared in line with the guidelines regarding to structure and form of the national reports (INFCIRC/604/Rev.2 from September, 2012). This report is prepared by the Chilean Nuclear Energy Commission, **CCHEN**, in order to meet the provisions of the Convention.

In Chile, nuclear and radioactive activities started during the sixties along with the creation of the CCHEN, public nonprofit entity with autonomous management of State and own assets. It relates to the Supreme Government through the Ministry of Energy and is responsible for the development of nuclear science and technology in the country.

CChEN's institutional mission is to conduct research, development, applications of nuclear energy; and its regulation, control and supervision, providing technological services, investigation and development to external sectors such as Ministries, State Institutes, Public and Private enterprises, Universities and Educational establishments, so that entails an effective contribution to science and technology knowledge, welfare, safety of people and environmental protection.

In Chile there are no nuclear power plants and it is not planned to have them in the near future. The existing nuclear facilities administered by CChEN are the following:

- *A nuclear research reactor with a capacity of 5 MWt* (RECH-1: Experimental Chilean Reactor N° 1).
- *A nuclear research reactor with a capacity of 2 MWt* (RECH-2: Experimental Chilean Reactor N° 2).
- *Production plant of MTR type fuel element.*
- *Plant of conversion from UF6 to uranium metal.*

The RECH 1 nuclear research reactor was commissioned in 1974, date from which spent fuel has been stored in its decay pool. The fuel elements of 80% enrichment of the reactor were sent to the Department of Energy of the United States until 1998 and those of 45% enrichment were sent in the year 2010.

The nuclear research reactor RECH 2, is in extended shutdown and without nuclear fuel. The 90% enriched fuel elements were sent to the US Department of Energy in 2010 as part of its high-enrichment uranium collection program.

On the other hand, CNEC, taking into account the principles under which it was created, consisting of the well-being and safety of the population with respect to the uses given to nuclear energy in the country, and taking advantage of its own developed infrastructure, assumed as its own initiative to attend the external requirements for the management of radioactive waste generated by activities using radioactive isotopes; for which from the 90's the Radioactive Waste Management unit was created.

The main radioactive waste generated in Chile comes from applications of nuclear techniques, hospitals, industries and research centers, with the most frequent sources of sealed radiation. In addition, elements from facilities that work with contaminated

radioactive material and classified as heterogeneous and compactable and ion exchange resins from the reactor are managed.

SECTION B – POLICIES AND PRACTICES

B.1 Spent Fuel Management Policy

Chile does not have an approved policy for spent fuel management, not contemplating specific regulations for SF Management. Our country adopted the policy of reducing the uranium enrichment in fuels from the research reactors, for which it signed an agreement with the IAEA in 2006. The implementation of this policy reduced the U-235 enrichment from 90% highly enriched uranium to less than 20% low-enriched uranium.

The spent fuels generated from the operation of the research reactor, to which, at present, they are not expected to be used later, have been chosen to have them for the time being in wet storage, however, if the spent fuels are kept in the For decades, one could expect corrosion degradation, while maintaining water quality at the recommended levels.

In our country, the search for a temporary solution for the safe storage of spent fuel elements generated by the operation of the CCHEN reactors has a high institutional importance.

Dry storage in prolonged and interim conditions is the option that best adapts to the current conditions of the country's nuclear development. This option complies fully with the fundamental criteria of containment, confinement and recoverability.

A container for interim dry storage of the spent fuel elements of the CCHEN reactors has been designed. In order to verify the nuclear and radiological safety conditions, a criticality and shielding analysis has been carried out for this conceptual design.

This activity was developed within the framework of Project RLA / 3/004 "Spent Fuel Management for Research Reactors" for the 2005-2006 biennium. The country has not made the determination to carry it out.

Our country adopted the policy of reducing the enrichment of uranium from the fuels of its research reactors, for which an agreement was signed with the IAEA. The implementation of this policy allowed for the reduction of high enrichment uranium of 90%, to 45% enrichment and subsequently to less than 20% of low enrichment uranium.

B.2 Spent Fuel Management Practice

The spent fuel generated in Chile comes from the RECH-1 research reactor located in the Centre for Nuclear Studies in La Reina, Santiago. The total mass of U-235 in the core is of 5 kilograms. The fuel is used until reaching an average burned of 40% of U-235, and then is kept in wet storage-waiting for an interim storage.

Since the beginning of the operation of nuclear research reactors, the management of spent fuel has been the wet storage in pools.

From cooperation agreements, in 2000, 2002 and 2010, with the United States Government, Chile transferred its spent fuels for storage and management to USA.

Currently, and as the country decides an appropriate and definitive solution to the extended interim storage, low enriched fuel elements will be stored in the RECH-1 pool for heat dissipation and fission products decay.

B.3 Radioactive Waste Management Policy

Chile does not have an approved radioactive waste management policy, however there is a legislative and regulatory framework that addresses aspects of safety and radiation protection applicable to the management of radioactive waste generated in the country.

The Law establishes that it will be the responsibility of the operator (Legal Representative) to provide the necessary means for the treatment and definitive storage of the radioactive waste and will not be able to store radioactive waste in national territory, unless they are produced or originated in it.

It will be the responsibility of CNEC to maintain and protect the national infrastructure for the management and permanent storage of nuclear or radioactive waste of long-lived.

Radioactive waste in Chile, from the applications of industry, medicine, research and teaching are low and medium activity.

The management and storage of radioactive waste generated in the country is carried out by the CNEC through the radioactive waste management section, SEGEDRA, which is duly authorized by the regulatory authority in compliance with current regulations.

Chile does not have a final disposal facility and the State has not ruled on this, that is why the radioactive waste is conditioned and stored in SEGEDRA so that it can comply the acceptance criteria in a future final disposal facility.

Only some facilities in Chile, such as research reactor and medical , have been authorized for the discharge and / or disposal of radioactive waste to the environment based on the recommendations of the IAEA.

On the other hand, the regulatory authority has not implemented the use of exemption limits in the management of radioactive waste.

B.4 Radioactive Waste Management Practice

In Chile, any material containing radionuclides or contaminated by them is considered radioactive waste, with total activities or activities exceeding the exemption levels established by the regulations and for which no use is foreseen.

CNEC is the only authorized entity in the country for the management of radioactive waste, it is therefore that through SEGEDRA, most of the radioactive waste generated in the country is managed, except the waste for the very short half-life from medical facilities.

Radioactive wastes are generated and come from the following practices:

- Production of Radioisotopes: in the processes of separation and purification in hot cells, small volumes of liquid radioactive waste of intermediate level and higher volumes of solids of low activity as papers and laboratory material are generated. The generated waste is stored in the cell, to be removed, transferred to the radioactive waste management facility and arranged in a place for its natural decay.

- Medical applications: that use nuclear techniques in both diagnosis and treatment of patients, mainly from nuclear medicine using radioisotope I-131 for clinical therapy. In clinical diagnosis and therapy monitoring, the main radioisotopes used areTc-99, P-32, Y-90 and Sm-153. Nuclear medicine facilities manage their own radioactive waste, since the radioactive material used corresponds to radioisotopes with a half-life of less than 100 days. All radioactive material generated as waste is stored in a duly authorized place. Radioactive waste is stored for at least 10 half-lives, and can then be managed as non-radioactive waste if the dose rate is less than 3 times the bottom measurement.
- Another medical application that generates radioactive waste from the practice of radiotherapy is tele—therapy, where sealed sources Co-60 are used and in brachytherapy sealed sources Cs-137 and Ir-192 are used; these sources are managed as radioactive waste in SEGEDRA.
- Industrial applications such as nondestructive testing, mainly industrial gammagraphy, using sealed sources of Ir-192, Se-75 and Co-60; nuclear gauges like thickness, level, and humidity gauges and food sterilization. Generally, all these sources are returned to the supplier, otherwise they are managed in SEGEDRA. Most of the industrial sources of category 3, 4 and 5 of IAEA are managed in SEGEDRA.
- There are also research facilities such as metabolic and toxicological studies associated to different compounds such as drugs, pesticides, fertilizers and minerals. They are related to production of new drugs, agricultural research and environmental studies. The generated waste mainly contains C-14 and H-3, because they can easily be incorporated into complex molecules.
- In compounds marking using I-125, I-131, H-3 and C-14, generated waste consist of laboratory materials, paper, personal protective clothing and commonly are of the order of MBq.
- In research, in solid state physics, post-radiation behavior of materials, development of reactor materials and non-destructive testing, H-3 and C-14 are the main radioactive contaminants and the wastes are lab material; heterogeneous solid (ion exchange resin, equipment pieces containing depleted uranium and fission products such as Cs-137 and Sr-90).

B.4.1 Criteria used to define and categorize radioactive waste

The classification of radioactive waste in Chile is according to the half-life of radioisotopes, in relation with the internal regulations of the CChEN. corresponding to:

- **Category 1:** Alpha emitting radioisotopes, whatever their activity.

- **Category 2:** Radioisotopes with beta and gamma emitters whose half-life is greater than 100 days.

- **Category 3:** Radioisotopes with beta and gamma emitters whose half-life is less than 100 days.

To facilitate handling and management of the radioactive waste can be classified internally into compactables, heterogeneous, granular, sealed radiation sources and organic or aqueous liquids.

SECTION C – APPLICATION SCOPE

In accordance with Article 3(1) of the Joint Convention, Chile does not perform reprocessing as part of spent fuel management.

In accordance with Article 3(2) of the Joint Convention, the present National Report does not consider natural radioactive materials.

In accordance with Article 3(3) of the Joint Convention, Chile has not destined radioactive waste and/or spent fuel in military or defense programs.

SECCION D – INVENTORIES AND LISTS

D.1 Inventory of radioactive waste in Chile, according to processing:

Next, in table N°1, Below is a summary of the SEGEDRA inventory. Every year, SEGEDRA receives approximately 10 to 20 m3 of radioactive waste, which must subsequently be treated and conditioned. Of the total volume received, 40% corresponds to sealed radiation sources in disuse.

In the following table, the current inventory (year 2017) of radioactive waste stored in SEGEDRA facilities is presented

Table N°1. Inventory Summary

Amount	Unit	Type	Description	Location	Category	Percentages
1830	Liters	Liquid radioactive waste	Concentration activity in MBq per gram	Storage ponds within the radioactive waste treatment plant	Category 1	100%
12	Cubic Meters	Ion Exchange resins	Concentration activity in KBq per gram	Storage facilities for the research reactor's ion Exchange resin	Category 2	100%
38	Cubic Meters	Compactable sealed sources heterogeneous and cemented liquids	Distributed in immobilized packages conditioned of 200 liters	Storage facility for radioactive waste	Category 1 Category 2	20% 80%
15	Cubic Meters	Disused sources of teletherapy	activity measured in TBq		Categoría 2	100%
2	Cubic Meters			Container Temporary Storage	Categoría 2	100%
8	Cubic Meters	Short-life radioactive waste	With average activity concentrations of kBq to MBq per gram	Storage facility for radioactive waste / Modular Temporary Storage Facility	Categoría 2 Categoría 3	10% 90%

The radioactive waste that is received at CCHEN comes from nuclear applications in Industries, Hospitals, Universities and CCHEN itself. Table N ° 1 presents the percentage in volume of the origin of the radioactive waste of the country, which has been managed in CCHEN from 2005 to 2016.

Table N°2. Origin of radioactive waste managed in CChEN per year, in percentages

GENERATOR	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Hospitals	11	0	33	16	7	8	10	0	22	27	9	13
Universities	11	13	4	4	10	6	0	2	4	0	2	0
Industries	49	28	59	44	39	18	26	63	26	29	71	63
CCHEN	29	59	4	36	44	68	64	35	48	44	18	25
TOTAL, %	100	100	100	100	100	100	100	100	100	100	100	100
TOTAL, m^3	10	3.9	9.5	9.2	7.1	11	10	20	4.5	12.2	10	8

Source: SEGEDRA, Chilean Nuclear Energy Commission

According to the physical-chemical and radiological nature of these wastes, they have been classified into heterogeneous, granular, compactable, sealed radiation sources, organic and inorganic liquids, according to which the treatment and subsequent conditioning that will be given with the object of configuring a package of radioactive waste that can remain in the environment under controlled safety conditions, this is concentrated and confined to a minimum dose at its contact, thus giving security to the most exposed individuals, the public and the environment.

Table N ° 3 presents the percentage of the types of radioactive waste managed in the last 8 years, and the total volume of waste managed per year. The majority of the radioactive waste managed by SEGEDRA corresponds to compactable material and disused sealed radiation sources; the latter, in an average amount of 100 to 150 units per year, mainly from mining and industries.

Table N° 3. Types of radioactive waste generated in Chile, from 2005 to 2013

Type of waste	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Heterogeneous	3%	21%	0.3%	1%	5%	5%	0,2%	0.5%	1%	11%
Granular	0%	0%	0.7%	2%	0%	0%	0%	3.25	0%	0%
Inorganic liquids	0%	7%	1%	0%	0%	0.2%	0%	0%	0%	0%
Organic liquids	0%	0%	1%	3%	1%	1.8%	0%	0%	1%	0%
Sealed radiation sources	76%	53%	57%	33%	33%	64%	2,1%	6.7%	81%	71%
Compactable	21%	19%	40%	61%	61%	29%	2,2%	1.8%	18%	17%
TOTAL VOLUME m^3/year	9,5	9,2	7,1	11	10	20	4,5	12.2	10	8

Source: SEGEDRA, Chilean Nuclear Energy Commission

Currently there is an approximate amount of 84m3 of radioactive waste in CCHEN, product of nuclear applications in the country, that come from CCHEN and from external radioactive facilities. Of these, a volume of 53m3 is stored in conditioned form. The capacity of the Radioactive Waste Storage Facility, IADRA, located at CEN Lo Aguirre, is 48 m3, a capacity that is currently 100%.

The rest, a volume of 30 m3 is awaiting treatment and a volume of 1.6 m3 is in the processing stage. Table N°4 presents the current inventory of radioactive waste in the radioactive waste management facilities of CCHEN.

TABLE N°4. Inventory of Radioactive Waste in CChEN

FACILITY	**WASTE AWAITING FOR PROCESSING** m^3	**WASTE IN PROCESS** m^3	**CONDITIONED WASTE** m^3
RADIOACTIVE WASTE LA REINA	19	0	0
TREATMENT PLANT LO AGUIRRE	5.2	1.6	0
CONDITIONED RADIOACTIVE WASTE LO AGUIRRE	1.5	0	0
OPERATIONAL WAREHOUS	1.5	0	0
RADIOACTIVE WASTE CONDITIONED LO AGUIRRE	2	0	53
TOTAL VOLUME m^3	27	1.6	53

D.2 Inventory of Spent Fuel in Chile:

Next in table No.5, it is shown the inventory of spent fuel in wet storage until 2014. Values of total uranium and grams of uranium 235 are obtained.

Table N°5. Spent fuel in wet storage

LOCATION	IDENTIFICATION NUMBER	TOTAL URANIUM [g]	URANIUM 235 [g]
11	LR 01 L	991.04	108.21
15	LR 02 L	989.86	106.55
12	LR 03 L	993.62	110.61
14	LR 04 L	993.22	110.12
13	LR 44	1013.94	129.93
14	LR 45	1013.15	129.09
4	LR 51	1031.79	131.03
4	LR 55	1032.05	131.37
6	LR 59	1033.46	133.08
2	LR 82	1024.79	132.26
	TOTAL	**10116.92**	**1222.25**

SECTION E – LAW AND REGULATION SYSTEM

E.1 Regulatory framework description

The Law of Nuclear Safety (Law No. 18.302) on its article No. 2, establishes that regulation, supervision, control and inspection of the activities related to the pacific use of nuclear energy, facilities and materials correspond to the CCHEN and the Ministry of Energy.

Article No. 4 of the same Law states that for the location, construction, commissioning, operation, closing and decommissioning of facilities, plants, laboratories, centers, and nuclear equipment needs authorization of CChEN.

On the other hand, nuclear power plants, enrichment plants, reprocessing plants and permanent storage deposits of radioactive waste, shall require to be approved by Supreme Decree issued through the Ministry of Energy.

The CChEN has the function to regulate, monitoring, controlling and supervising all the activities related to the pacific use of nuclear energy along with the facilities and nuclear substances used in them, in order to contribute to health protection, security, people safety, goods and the environment.

CChEN complies with dual roles; as Competent Authority and Operator of Nuclear and Radioactive facilities.

The Chilean government has jurisdiction over the CChEN, autonomous body of the state administration governed by provisions of the law, rules and regulations. It relates to the supreme government through the Ministry of Energy and it is managed and administered by a Board of Directors.

Some of the functions of CChEN in the regulatory field of nuclear safety are to promote a safety culture at national level; to strengthen the skills of workers that form the regulatory body, systemize communication to various interest groups, improving the knowledge they have about the regulatory function and incorporate them in the regulatory process; and

permanently update the rules, so that suits national needs in line with international best practices.

E.2 Legislative and regulatory framework

The hierarchy of the regulatory framework is based on:

1° National Constitution.
2° Constitutional Organic Law.
3° Law and Law Decree:
4º Supreme Decree.
5º Rules.

The legislative and regulatory framework applicable to nuclear and radioactive facilities in Chile is defined by the following laws and regulations:

a) Law Nº 18.302: 1984's NUCLEAR SAFETY LAW. This law has six titles: OF REGULATORY AUTHORITY, defines the different regulation bodies and their respective application scopes, NUCLEAR SAFETY DEFINITIONS, establishes the general criteria related to nuclear safety, including authorizations and requirements to operate a nuclear facility, the obligation to inform and the inspections, VIOLATION OF LEGAL RULES ON SAFETY AND NUCLEAR PROTECTION, establishes the penalties that can be applied in case of non-compliance, CIVIL LIABILITY FOR NUCLEAR DAMAGE, sets the amount and types of insurance that cover nuclear damage, OF RADIOACTIVE FACILITIES, sets the competent authority for the control of radioactive facilities, the responsibility of the elaboration of rules applicable to those facilities and competence to propose new regulations on radiation protection and nuclear security lies in the CChEN. The regulations related to radiation protection and authorization as a supreme decree shall be proposed by the Ministry of Health and the Ministry of Energy.

b) LAW N° 19.300: LAW OF GENERAL RULES OF THE ENVIRONMENT, from April, 1994. This law has six titles: GENERAL ASPECTS, ENVIRONMENTAL MANAGEMENT TOOLS, Sets projects requiring environmental assessment. Projects requiring environmental assessment include nuclear power stations, nuclear facilities and related, and production, storage, transportation, disposal or reuse of radioactive material, LIABILITY FOR ENVIRONMENTAL DAMAGE, INSPECTION, ENVIRONMENTAL PROTECTION FUND, NATIONAL COMMISSION OF THE ENVIRONMENT.

c) Supreme Decree Nº 115/76: APPROVES BASIC RADIATION PROTECTION STANDARDS, from April, 1976.

d) Supreme Decree Nº 87/84: REGULATION ON PHYSICAL PROTECTION OF NUCLEAR MATERIAL AND NUCLEAR FACILITIES, from 1984.

e) Supreme Decree Nº 133/84: REGULATION OF AUTHORIZATION OF RADIOACTIVE FACILITIES OR EQUIPMENT THAT GENERAL IONIZING RADIATION, PERSONNEL WORKING IN THEM, OR OPERATE SUCH EQUIPMENT AND OTHER RELATED ACTIVITIES, from August, 1984. This decree classifies the different radioactive facilities, according to the risk of the practice, required authorizations and associated requirements for facilities and workers, including import, export and radioactive material transportation and how to apply sanctions.

f) Supreme Decree Nº 3/85: REGULATION ON RADIATION PROTECTION OF RADIOACTIVE FACILITIES, from January, 1985. Establishes the acceptable dose limits (based on No. ICRP 26) and the requirements for personal dosimetry services provided in the country.

g) Supreme Decree Nº 12/85: REGULATIONS FOR THE SAFE TRANSPORT OF RADIOACTIVE MATERIAL, from June, 1985. This is a transcript of the 1985 version of the Safety Guide No. 6 from the IAEA "Regulations for the Safe Transport of Radioactive Material".

h) Supreme Decree N° 40/2013: REGULATION ON THE ASSESSMENT SYSTEM OF ENVIRONMENTAL IMPACT. Published in the Official Gazette on August 12, 2013. Establishes a categorization of projects according to the potential environmental damage and the procedure for carrying out the environmental assessment of each category.

Chilean Law does not establish a licensing process for nuclear facilities, except for the mention in the Nuclear Safety Law, which indicates that nuclear facilities require authorization for siting, construction, operation and decommissioning. The decree used to issue authorizations for radioactive facilities is the Supreme Decree 133/84. For technical issues that are not regulated in national standards, including the case of nuclear facilities is the adoption of the IAEA recommendations or the supplier country regulations, when there are no specific guidance documents from the IAEA.

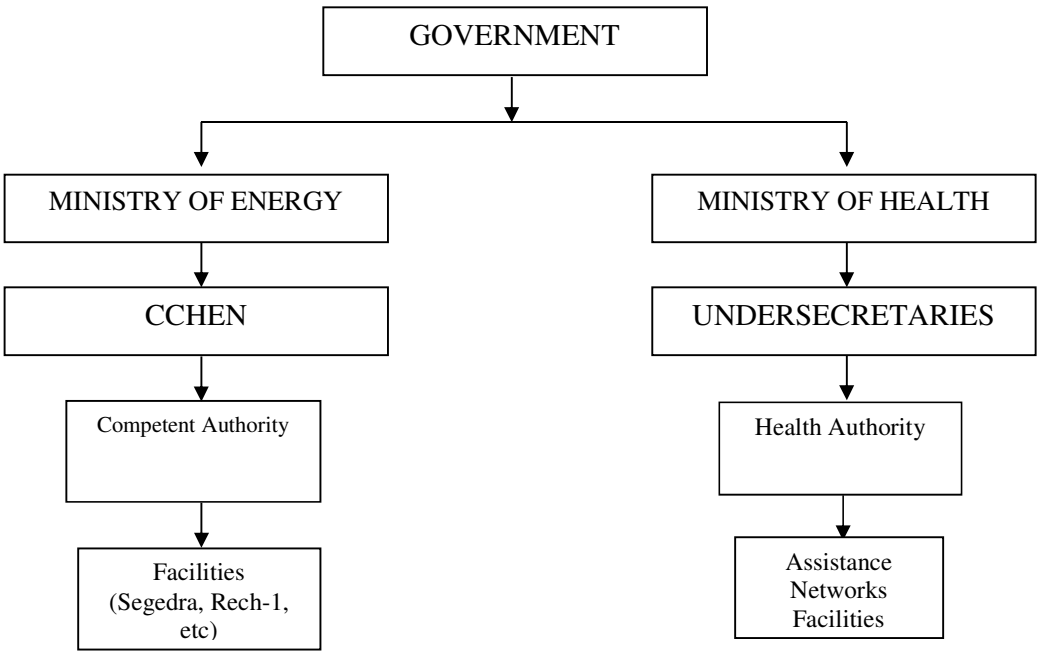
i) Internal Safety regulation of CChEN: NCS-DR-01 "Radioactive Waste Management".

E.3 Regulatory Body

The Chilean government has jurisdiction over the CChEN and undersecretaries through the Ministry of Energy and Ministry of Health. The country has two regulatory bodies to control and monitor nuclear and radioactive facilities:

- CCHEN Competent Authority in charge of first class radioactive and nuclear facilities, which possess higher activity and radiotoxicity.
- Ministerial Regional Health Undersecretaries (Health Regional Offices): Competent Authority in charge of second and third class radioactive facilities, which possess low-activity radioisotopes.

Figure 1: Organization chart of Chile's regulatory body



According to the Law Decree No. 133/84 "Regulations on authorizations for radioactive facilities or generating equipment of ionizing radiation, personnel that operate such equipment and other activities", radioactive facilities are classified into the following categories:

1st Category:

- Particle accelerators
- Irradiation plants
- High toxicity radio laboratories
- Deep radiotherapy, industrial scans and X-ray

2nd and 3rd Categories:

- Low radiotoxicity laboratories
- Dental X-rays for medical or dental diagnosis
- Superficial radiotherapy
- Industrial gauges
- standard sources

SECTION F – OTHER GENERAL DISPOSITIONS RELATED TO SECURITY

F.1 Responsibility of the licensee

The main responsibilities of the operator of the license are:

a) Comply with the limits and conditions established in the authorization.

b) Take responsibility for nuclear or radioactive damages that could occur in the facilities under its control.

c) Meet the requirements of the competent authority on the amount of authorized people to work in each facility, plant, center or laboratory.

d) Provide the necessary means for the treatment and definite storage of radioactive waste. It is forbidden to authorize nuclear or radioactive waste in the country, unless they are originated in it.

e) Develop and maintain emergency plans reviewed and approved by the regulatory body for radioactive or nuclear accidents that may occur in their facilities.

f) Prevent damages arising from theft or loss of nuclear substances and radioactive material.

g) Provide, to the requirements of the regulatory body, enough guarantee for decommission and comply with any requirement established in the regulation, when giving up a license or authorization.

F.2 Human and financial resources

The legislation provides operator with the obligation to have an amount of qualified people determined by the Competent Authority. These people with special authorization to work in radioactive facilities will receive adequate training on the risks it involves and the security measures that will have to comply.

Financial resources for the maintenance and protection of permanent storage deposits for long-lived radionuclides and nuclear waste is a responsibility given to CChEN by Nuclear Security Law No. 18.392

Regarding to radioactive waste that are not "long-lived", the national legislation demands to the operators of radioactive facilities the safe management of radioactive waste generated in them, thus operators must consider the financial costs.

CChEN's nuclear and radioactive facilities are state-owned; the State covers the financial costs for installation and operation of radioactive waste and spent fuel.

National legislation does not explicitly state the requirement of financial resources that should have on nuclear and radioactive facilities for decommissioning and dismantling program.

F.3 Quality assurance

All CChEN facilities, including radioactive and spent fuel management, are under a quality management program being audited periodically. This quality program is based on the system norm of quality management of ISO 9001:2008 requirements and each facility has its own quality plan.

Regarding quality assurance, SEGEDRA has a quality management system based on ISO 9001: 2015, a system that allows traceability to each of the stages of the radioactive waste management process from reception to storage prior to final disposal. .

The quality assurance of the fuel elements is obtained through a quality control system for each of the stages of the manufacture of the fuel elements.

In addition, control is implemented and recorded for tracking the fuel elements from their entry into the core to storage in the decay pool. This quality control is through measurements and tests of the different parameters related to the FS.

F.4 Operational radiation protection

The norm that refers to the legal requirements on radiation is the Supreme Decree No. 3 from 1985, based on ICRP 26, which defines the dose limits, and establishes general conditions of radiation protection, as well as the requirements for personal dosimetry services.

Establishes personal radiation protection measures and radioactive dose limits that people that are occupationally exposed may receive, in order to prevent and avoid overexposure to ionizing radiation and its effects on health.

For the operation of radioactive waste management and spent fuel facilities in the country, CChEN has established radiation protection programs such as "Operational Radiation Protection Manual" to establish lower dose limits to the ones set by law and assure safe procedures during operation, personnel protection and the public from unnecessary exposure to ionizing radiation.

Annual limits for individuals from the public will be equal to 1/10 of the corresponding maximum permissible doses indicated according to the Supreme Decree No. 115/76. The dose limits for workers exposed to ionizing radiation shall be:

Exposed organ	*Dose limits*
Whole body, gonads, bone marrow	5 mrem/year
Eye's lens	30 mrem/year
Any other body organ individually	50 mrem/year

There is a radiological surveillance program in nuclear research centers and radioactive waste facilities from CChEN consisting in dose rate measurements, surface contamination and air pollution. Besides environmental radioactivity monitoring is performed in different areas of the CChEN to ensure the protection of workers and the public from unnecessary exposure to ionizing radiation.

F.5 Emergency preparedness

The Nuclear Safety Law requires that each operator must have an emergency plan that covers the whole spectrum of possible events in a particular facility.

In this regard, CChEN has prepared emergency plans for its two nuclear centers; La Reina and Lo Aguirre, considering emergency situations that also involve areas outside the site.

The CChEN, in collaboration with the National Emergency Office under the Ministry of Interior, is developing the "National Radiological Emergency Plan". In this plan, it is proposed to conduct emergency drills and exercises in coordination with other agencies involved in emergency management.

The facilities of radioactive waste and spent fuel management have a Radiological Protection Operational Manual approved by the Regulatory Authority, which includes a chapter on emergency situations of each facility.

F.6 Closing

There are no facilities of spent fuel or radioactive waste in closing process, however, when it is required, shall comply with regulatory safety aspects required through closure authorization, which will be requested by the operator and issued by the Regulatory Authority.

SECTION G – SAFETY ON SPENT FUEL MANAGEMENT

G.1 General Safety requirements

CChEN must ensure the safety of individuals, society and the environment, and adequately protect them in all stages of radioactive waste and spent fuel. This is achieved through the Chilean regulatory regime. When there is no legislation, rule or regulation to a safety issue, Chile adopts recommendations, guidelines and safety practices from IAEA.

G.2 Existing Facilities

Chile has a research reactor in operation of 5 MWt located on the premises of the Center for Nuclear Studies in La Reina, from the

The research reactor consists of three sectors:

1) Warehouse: Place where fresh fuel is stored
2) Reactor core: Consists of 32 fuel elements
3) Decay pool: Temporary storage location of spent fuel

G.3 Location of proposed facilities

Currently there is no proposed facilities location for spent fuel. The country has not made a decision on disposal for storing spent fuel.

G.4 Design and Construction of facilities

There is no current construction of facilities for spent fuel. The country has not made a decision on disposal for storing spent fuel.

G.5 Safety evaluation of facilities

There have been no changes to the established requirements for accomplishing the safety evaluation of the spent fuel facilities.

G.6 Operation of facilities

In Chile, spent fuel is stored in a decay pool located on the side of the reactor pool. Spent fuel is not managed as waste, it is only stored in wet for several years and in that time spent fuel will not be manipulated while maintaining stored.

There have been no changes to the established requirements to accomplish the operation of spent fuel facility.

G.7 Disposal of spent fuel

Chile has not made a decision on spent fuel disposal.

SECTION H – SAFETY IN RADIOACTIVE WASTE MANAGEMENT

H.1 General Safety requirements

Chile must ensure the safety of people, society and the environment and adequately protect them in all stages of radioactive waste management. This is achieved through the national regulatory regime, exercised in this case by the CChEN. When there is no legislation, regulation or norm for a nuclear safety issue, Chile adopts the recommendations, guides and safety practices of the IAEA.

H.2 Existing facilities and past practices

In Chile there is a set of facilities within the Radioactive Waste Management Section, SEGEDRA, located in the CChEN headquarters, Lo Aguirre and La Reina, and it has three facilities:

1) **Installation of Radioactive Waste - La Reina:** destined for those wastes of very short half-life, generated in decay, in majority, in the CEN La Reina, and that after a predetermined period (due to its radiological characteristics) and then of a monitoring can be delivered as common trash, if its level of radioactivity has fallen to the natural range and does not have in its composition dangerous chemical elements. This installation considers, has the following work areas.

a) **Laboratory of segregation:** where the tasks of processing, characterization and segregation of decaying radioactive waste are performed.

b) **Well of Ion Exchange Resins:** Installation designed for decay of ion exchange resins.

c) **Modular Temporary Storage Facility:** a facility designed and built to temporarily store the radioactive waste generated from the dismantling of the Radioisotope Production Laboratory at CEN La Reina, waste is stored for a very short half-life, but with high radiation doses.

2) **Radioactive Waste Treatment Plant:** It has an area for the treatment of liquid and solid waste. The treatment consists of reducing the volume of the radioactive material in order to confine a smaller volume than the original one, in benefit of the economy in the management of radioactive waste. After treatment, the waste is conditioned in cementitious matrices, giving a solid form for storage prior to disposal. This form of storage is recommended by the International Atomic Energy Agency.

a) **Laboratory of Experimentation and Instrumentation:** Where research is developed to process, characterize and define lines of treatment of radioactive waste.
b) **Liquid Radioactive Waste Storage Area:** where radioactive waste, whether organic or aqueous, is stored awaiting treatment
c) **Operational Warehouse:** area where sealed radiation sources are stored awaiting treatment or those whose treatment has not been defined.
d) **Liquid Treatment Plant:** Area destined to the treatment of liquid radioactive waste contaminated with uranyl nitrate.

e) **Container Temporary Storage:** Area that allows the temporary storage of conditioned radioactive waste, pending the construction of the new storage facility.

3) **Storage of Radioactive Waste Storage:** Specially designed to keep in a controlled manner and under conditions of radiological safety, such as physical, radioactive waste that has been conditioned to remain in the environment without the risks associated with its danger.

H.3 Location of the proposed facilities

Chile is considering a new storage installation project for conditioned radioactive waste, whose first works will begin at the end of 2017, projecting the start of the heavy work by 2018.

This facility will be located at CEN Lo Aguirre, within the exclusion area.

H.4 Design and Construction of facilities

Chile is considering a new storage installation project for conditioned radioactive waste, whose first works will begin at the end of 2017, projecting the start of the heavy work by 2018.

H.5 Safety Evaluation of the facility

The safety evaluation of radioactive waste facilities established in the Law No. 18.302 of Nuclear Safety is associated with a number of limits and safety conditions required by the Competent Authority. Inspectors verify that the license conditions, radiological safety, physical security and operation procedures are accomplished and thus is guaranteed that there are no risks to health, safety or the environment.

H.6 Operation of facilities

One of the facilities of SEGEDRA, is the Radioactive Waste Treatment Plant (PTDR), described below is the operation of the facility:

a) Operation requirements:

- The facility possess its current operating license
- The staff possess their valid operator authorization
- Operating and safety systems are suitable
- The radiological monitoring is operational
- The ventilation system is operational
- Operating staff use personal protection assigned
- A responsible facility professional.
- The entry and exit of the staff take place through the changing clothes room, with radiological checks at the exit.
- Clear and clean working and access areas.

b) Operational Processes:

- Reception, admission and registration of radioactive waste
- Radioactive waste processing
- Non-conforming product control
- Management of liquid effluents generated in treatment plant of radioactive waste
- Solid radioactive waste compaction
- Conditioning of sealed radiation sources in disuse and heterogeneous waste
- Preparation of containers for solid radioactive waste conditioning
- Entry of radioactive waste to SEGEDRA facilities
- Preparation and quality control of mortar
- Segregation and sampling of granular waste from drums
- Effluents shipment from the treatment plant of radioactive waste to the Liquid Control System Storage Tanks.
- Decontamination of surfaces and equipment
- Sampling of stored effluents
- Emptying

H.7 Institutional measures after closure

It has not implemented any institutional measure, because it has not been planned or held the closure of radioactive waste or spent fuel management facilities.

SECTION I – CROSS-BORDER MOVEMENTS

Cross-border movements are performed to carry out the return of decayed sealed sources or in disuse to the country of origin, transport of radioactive material and sometimes to remove the spent fuel waste generated by the reactor.

The Competent Authority grants an import and export authorization according to the Law Decree No. 133/84", indicated on permits for import, export, sale, distribution and radioactive waste storage, and radioactive substances will not be admitted into the country or sent out of it without the proper authorization of the Regulatory Authority. Also, the transfer to any facility of such substances must have an authorization and the locations for radioactive waste or substances must have permission of the Competent Authority.

According to regulation No. 12 "Safe Transport of Radioactive Material", establishes that any radioactive material transport will require approval of the Competent Authority. Modes of transport are by land, water or air, which must comply with the regulations. Before carrying any package that requires approval of the Competent Authority, the sender shall ensure that the Competent Authority of each country to which the package will be sent receives a copy of each certificate issued by the Competent Authority related to the package concerned. Furthermore, the sender shall notify each exposure to the Competent Authority of the country that will transport the shipment.

SECTION J – SEALED SOURCES IN DISUSE

In Chile, the Competent Authority establishes requirements in order to provide for health protection, safety and people protection, goods and the environment.

Disused sealed sources in Chile must be returned to its supplier or be managed as radioactive waste.

In Chile, there is no fabrication of sealed sources, which is why sources are imported. One of the practices that have a major demand of sealed sources is industrial gammagraphy that generally use Ir-192 and Se-75 sources with an approximately maximum activity of 3.7 TBq. Most sealed sources are small and their radioactivity can range from dozens to gigas of becquerels (Bq).

The Competent Authority is responsible for controlling the export and import of sealed sources in the country, provided that the applicant complies with all the documents and requested information.

When a sealed source is no longer necessary or its activity has decayed beyond its useful life, it can be treated as radioactive waste, to do that, the installation of the decayed radioactive source or in disuse shall transfer the source to the CChEN, specifically to Radioactive Waste Management Facility, or be returned to the origin or factory owner. To do that is necessary an export permit.

SECTION K – PLANNED ACTIVITIES TO IMPROVE SECURITY

Currently, Chile has several initiatives in order to improve radioactive waste and spent fuel management, thus ensuring the safety of human beings, society and the environment. These initiatives include:

1) Improve the storing capacity of radioactive waste:

It is planned to build a new Facility for Storage of Radioactive Waste with a capacity greater than the current one. It is planned to begin the construction of the thick work in 2018. The new installation is planned for 20 years of operation with a capacity of 138m3, distributed in 583 containers of 200L, and 45m3, for radiation sources sealed in containers of different configuration.

2) Develop long-term of dry management option on spent fuel:

During 2007, it took participation in RLA/3/004 on Management of Spent Fuel for Research Reactors.

3) Improve and implement new processes for radioactive waste management:

SEGEDRA, during the year 2015, developed an armored workbench, which allowed to evaluate the recovery process of sealed radiation sources, process that will allow the optimization of conditioning volumes, in addition in the same year, volume reduction was carried out of liquids contaminated with uranyl nitrate.

4) Participate in security projects on radioactive waste:

SEGEDRA will participate in security project in the operation to immobilize sealed sources in the regional project of technical cooperation for development and improvement of the management of sealed sources in Latin America.