NUCLEAR SAFETY ENDEAVOUR IN KOREA

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ABSTRACT

Korea's nuclear power plant program is growing. As it grows, nuclear safety becomes an important issue. This article traces the development of Korean nuclear power program, the structure of the nuclear industries, the Nuclear Safety Center and its roles in the regulation and licensing of nuclear power plant, and also identifies some of the activities carried out to enhance the safety of nuclear power plants.

1. INTRODUCTION

At present, Korea has nine nuclear power plants; eight in operation and one under construction. As Korea's nuclear power plant program expands to meet increasing energy demands, the safety of these nuclear power plants becomes an important issue. That is, for a successful nuclear power plant program, the safety of the plants at all stages of developments including site selection, design, manufacturing, construction, commissioning, operation and decommissioning must be assured.

The safety objectives are to protect the plant crews and neighbouring inhabitants from radiation hazards, as well as to minimize the consequences of radiation effects as low as reasonably achievable. Although the expressed criteria have changed somewhat with experience over the years, the basic objectives remain unchanged. For example, the Atomic Energy Act[1] (AEA) of Korea was largely revised in 1982 and 1986, to cope with increasing demands and advances of the nuclear technology. The AEA also outlined the establishment of the Nuclear Safety Center (NSC) within the organizational structure of the Korea Advanced Energy Research Institute(KAERI) in order to assist the Ministry of Science and Technology(MOST) in the regulation and licensing of the nuclear power plants.

This article traces the development of Korean nuclear power program, the structure of the industry, the NSC and its roles in the regulation and licensing of nuclear power plants, as well as presenting examples of ongoing activities carried out to enhance the safety of nuclear power plants (Ref. 2).

II. NUCLEAR POWER PLANT PROGRAM

Korea's electric power consumption has escalated over the years. In order to diversify sources of electric power supply and to alleviate unduly high dependency on oil, Korea has actively pursued the establishment of a nuclear power plant program. The nuclear electric power generation is projected to increase to around 53.8% by 1991, from the current 50%, while that of oilfired power plants will decrease to 22% from the current 41%. Table 1 shows the information on locations, capacities, reactor types, years of operation, suppliers and constructors of the nine nuclear power plants in Korea. More nuclear power plants are projected to be constructed in the future, for example, KNU-11 to 16

II.A. Korea Nuclear Industries

KAERI, formerly the Korea Atomic Energy Research Institute was founded in 1959 to serve as a center for research and development to promote the peaceful use of nuclear energy in Korea. At present KAERI consists of four major establishments:

1. Nuclear Safety Center, NSC
2. Daeduk Engineering Center
3. Cancer Research Hospital
4. Nuclear Training Center

KAERI is currently assigned to be responsible for the NSSS and fuel designs of KNU-11 & 12 and onward plants.

Korea Electric Power Corporation, KEPCO, a governmentowned and controlled company is the sole electric power utility in Korea. KEPCO has relied heavily on foreign vendors (principally the U.S.) to supply the nuclear power plants and set up an engineering subsidiary, KOPEC, in order to foster Korea's self-reliance in nuclear power

Table I. Nuclear Power Projects[a]

Korea Nuclear Unit No.	Location	Capacity, MWe	Reactor Type	Year of Operation	Suppliers			Constructors
					NSSS	T/G	A/E	
1	Kori, Yangsan-Gun, Gyeong Sang Nam Do	587	PWR	4/78	W	GEC	GAI	Hyundai, Dong-Ah
2	Same as the above	650	PWR	6/83	W	GEC	GAI	"
3	WolsungGun, Gyeong Sang Buk Do	678	PHWR	4/83	AECL	BBH/ NEI Parsons	CANA-TOM	"
5,6	Kori	950	PWR	85,86	W	GEC	BECHTEL	Hyundai
7,8	Yeonggwang-Gun, Jeolla Nam Do	950	PWR	86,87	W	W	BECHTEL	"
9,10	Uljin-Gun, Gyeong Sang Buk Do	950	PWR	88,89	FRAM/ COGEMA	AA	EBASCO (Consultant)	Dong-Ah
11,12	Yeonggwang-Gun, Jeolla Nam Do	900 Class	PWR	95,96	C-E	GE	SARGENT LUNDY	Undecided

[a] Referenced from Nuclear Programme[3] in Korea.

plant A/E technologies. KOPEC has made continuous efforts to achieve this goal through manpower training, project participation, system development, facility betterment and technical collaboration with foreign companies. There are numerous internationally known construction companies in Korea, for example, Hyundai, Dong-Ah, Daewoo established within Korea.

The decision to construct a nuclear power plant in Korea is made by KEPCO. Once a decision is made, NSC ensures that the facility complies with appropriate health, safety, security and environmental requirements of Korea.

II.B. The Nuclear Safety Center

NSC's organization, as shown on Fig. 1, consists of the Office of President of KAERI, Vice President of NSC, Directorate of Nuclear Safety Review, Directorate of Nuclear Safety Inspection, Directorate of Standards Development, and Project Administration Department.

The President of KAERI is Chief Executive Officer of NSC. He delegates his authority to the Vice President of NSC, who directs work in NSC.

The Directorate of Nuclear Safety Review is responsible for the regulation of the nuclear power plants. It encompasses reviews of the Final Safety Analysis Report(FSAR), evaluations and analyses of nuclear incidents, development and validation of safety analysis codes, evaluation of the structural integrity of the plants, and others.

The directorate of Nuclear Safety Inspection is reponsible for the inspection of nuclear power plants to ensure the compliance with technical specifications of the FSAR, and the modification and quality assurance functions. additional responsibilities include the operation of resident site officers and the radiation protection programs for licensing activities.

The Directorate of Standards Development is responsible for developing technical standards, regulatory guides, and safety criteria for siting and environment.

He is also responsible for the collection, retrieval and analyses of information relating to nuclear safety regulation and operation.

The Project Administration Department provides corporate management and administrative support services in areas of finance, human resources and information, international technical assistances, and others.

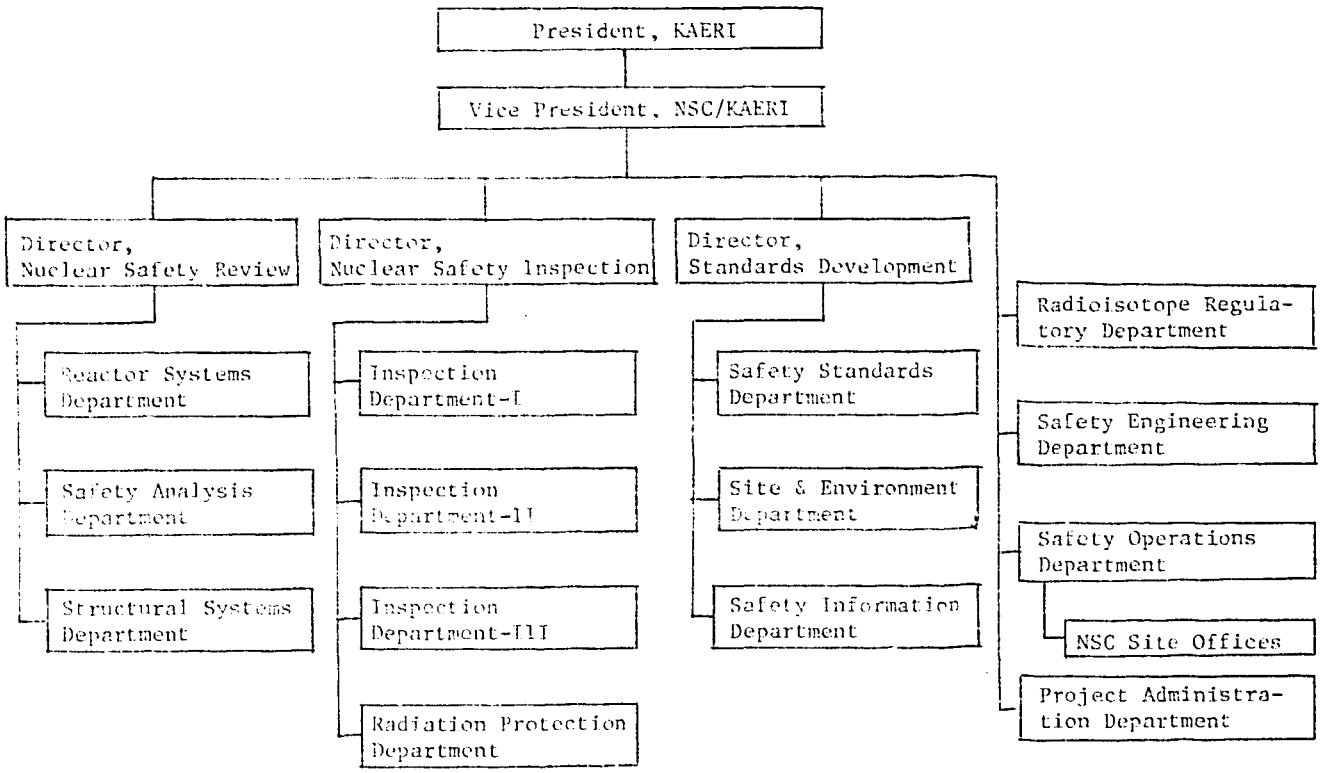

Fig. 1. Organization Chart of NSC

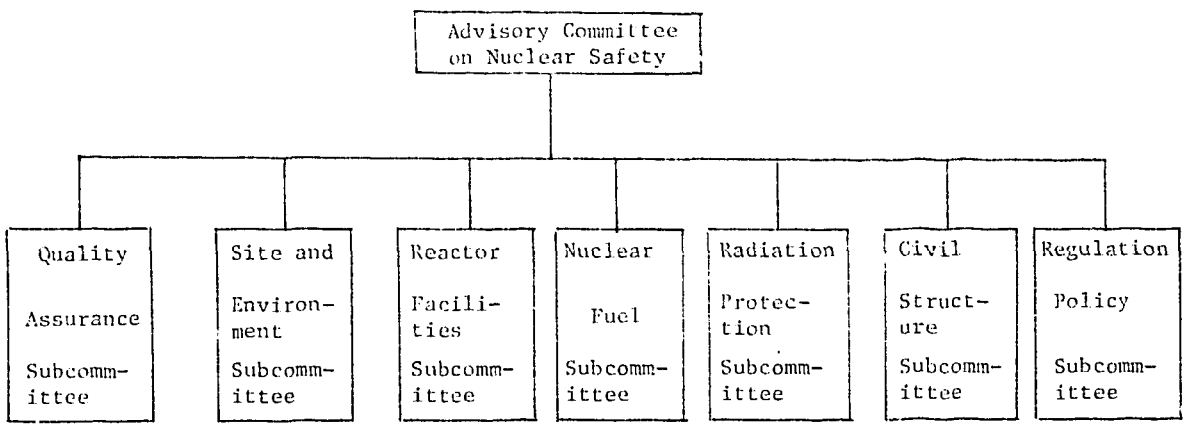

Fig. 2. Advisory Committee on Nuclear Safety

The Advisory Committee on Nuclear Safety (ACNS) operates as an advisory body to the NSC for the purpose of deliberating on major regulatory polices and safety issues. The Vice President of NSC is also the chairperson of ACNS(Fig. 2).

The NSC also obtains technical advices to improve nuclear regulatory capability and promote reactor safety research through international cooperation agreements. Multilateral and bilateral agreements are in effect with the International Atomic Energy Agency(IAEA), the US NRC, the French Commissariat a l'Energie Atomique(CEA), the Atomic Energy of Canada Limited(AECL) and the Atomic Energy Control Board(AECB). Additionally, technical cooperation agreements with NUTEC and Southwest Research Institute(SwRI) in the USA, the Gesellschaft für Reaktorsicherheit (GRS) of West Germany, and the United Kingdom Atomic Energy Authority(UKAEA) were established.

III. NUCLEAR SAFETY ENDEAVORS IN KOREA

The followings are some of ongoing activities that are being carried out in order to improve the safety of the Korean nuclear power plants:

III.A. Regulation and Licensing

Enforcement Regulation of Atomic Energy Act(AEA) is a Prime Ministerial Ordinance which prescribes details commissioned by the AEA and Enforcement Decree of the same Act. Specific requirements are imposed through this enforcement regulation.

The current regulations stipulate three stages of licensing nuclear power plants; siting and limited work authorization, construction permit, and operating license. Fig.3 illustrates the licensing stages and activities required for the nuclear power plant. Specifically, it shows the activities of the electric utility applying for the permits, NSC, and MOST at each stage of the licensing process.

The regulation also requires that any person or authority wishing to construct, operate and produce electric power in Korea is required to obtain a license from the MOST. Before issuing a license to the utility, the MOST requires sufficient information from the person or organization to show that the required technical, health, safety and security standards stipulated in the Prime Ministerial Ordinance are met and maintained.

MOST entrusted NSC with the responsibility to review and assess these informations which include FSAR, safety reports, computer codes, etc. Providing there is no conflict with the provisions of the AEA and the Enforcement Decree of the Act, NSC will recommend MOST the issurance of a permit or a license.

III.B. Safety Analysis and Evaluation of Nuclear Power plants

A number of foreign computer codes had been evaluated and used for the review of safety analysis reports submitted by the licensee. The computer codes used are:

1. RELAP 4/MOD 6, RELAP 4/MOD 7 and RELAP 5/MOD 1

These codes was used to perform analyses of loss of coolant accidents, LOCA, the upflow modification of KNU-1 and the blackout transient occurred in the same KNU-1 plant.

2. TOODEE-2

This code was used to analyze the single rod fuel heat-up of KNU-1 LOCA.

3. COBRA-I

This code was used for the multi-channel core thermal hydraulic analysis. In particular, this code was used to calculate the DNBR margin of the core fueled with the optimum fuel assembly and standard fuel assembly.

4. CONTEMPT-LT/29

This code was used for the review of containment analysis submitted in the FSAR.

Although most of the codes used are foreign in origin, emphasis has been placed to developing safety analysis computer codes domestically. It is expected that vendor codes will also be brought in via technology transfer program agreements.

III.C. Probabilistic Risk Analysis

Probabilistic Risk Analysis(PRA) group in KAERI was formed in 1981 to investigate the state-of-the-art PRA methodologies and applications. Most of the activities have, however, been concentrated on the evaluation of foreign system reliability analysis computer codes such as:

1. CAT-used for fault tree construction.
2. KILMER-used for fault tree plotting.
3. SETS-used for both qualitative and quantitative reliability analysis.
4. IMPORTANCE-II and FRANTIC-II-used for quantitative analysis.
5. CONINT-used for uncertainty analysis.
6. BERD-used for updating reliability data.

The computer codes 5 and 6 above were developed domestically. More computer codes are expected to be introduced and developed in the future.

The PRA group helps MOST review the analyses submitted in support of a license application. Further efforts will be required to improve the PRA capability in Korea.

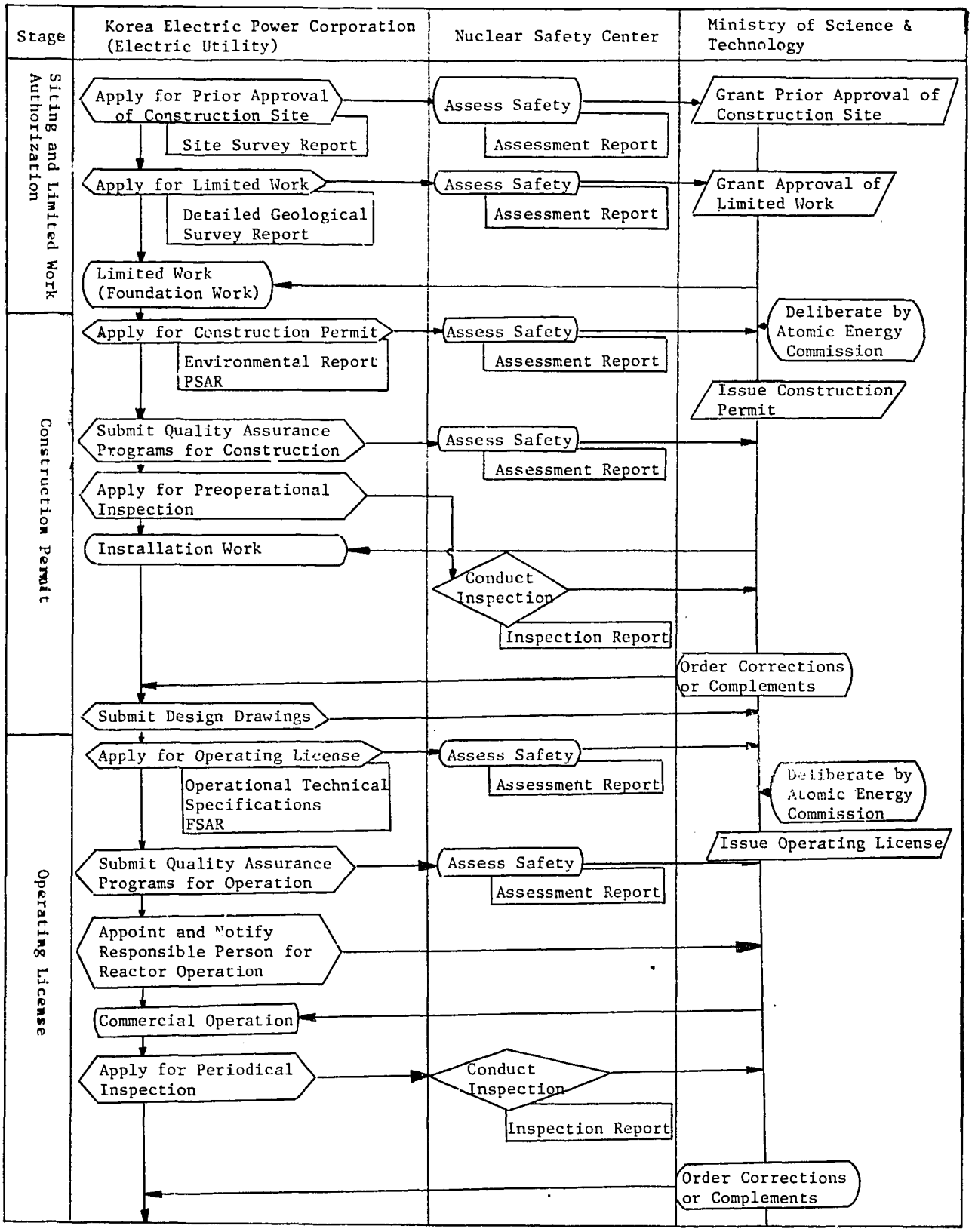

Fig. 3. Licensing Procedure for Nuclear Power Plants

III.D. R&D on Nuclear Safety

Numerous R&D on the operational safety of nuclear power plant were initiated. For examples:

1. Non-Destructive Testing

Non-Destructive testing methodologies have been developed and used for the inspection of KNU-1,2,5,6,7 and 8 pressure boundary and component integrity.

2. Pressure Vessel Surveillance Testing

Research activities to predict and evaluate the embrittleness of reactor pressure vessel materials due to neutron irradiation have been established for surveillance tests of KNU-1 and 2 pressure vessels. Future effort will emphasize in the development of fracture toughness tests and dynamic fracture toughness test technologies.

3. Flaw Analysis Technology

Two dimensioned flaw evaluation computer code, FAPCO was updated to take account of changes in ASME Sec XI. Three dimensional flaw analysis code is currently under development.

4. Study on Water Chemistry

Study on water chemistry has been performed to provide a safety index for accident prediction. Based on this study, the radioactivity of the KNU-1 primary cooling water has been analysed and a data base was established for future reference.

5. Environmental Safety of Radiation

Main activities include monitoring of the radiation level around the nuclear power plant, and development of methodologies to asses radiation effect on the ecological system and the standardization of environmental protection program.

6. Severe Accident

In collaboration with US NRC a severe accident research program has been carried out in Korea. It is expected that the results will be used to upgrade Korean regulation requirement and to improve the safe operation of the nuclear power plant. Currently, areas of interest are:

(1) behaviour of damaged fuel.
(2) fission product release and transport.
(3) severe accident sequence analysis.

III.E. Evaluation and Analysis of Nuclear Incidents

Evaluation and analysis of nuclear incidents research project was initiated in 1984. The purposes of this project were:

1. to collect data related to nuclear incidents that occurred at both domestic and overseas nuclear power plants.

2. to analyze their causes and event sequences.

3. to assess effects of such incidents on the safety of the plant, and to provide recommendations so that similar events are prevented. Table 2 shows the equipment improvement plan for KNU-1 & 2 as an example of results of this project.

III.F. Emergency Preparedness

As recommended by the Post-TMI nuclear power plant incident review report, MOST has required KEPCO to submit an emergency preparedness plan to MOST for review. This plan should be prepared in accordance with US NUREG-0654 Rev. 1 and must include an emergency plan for the province and local authority affected. Futhermore, the Republic of Korea Civil Defense Law, Article 10 and its Implementing Regulation, Article 11 requires KEPCO and the authorities affected to conduct a yearly exercise to evaluate the response of the emergency preparedness plan.

There is also the Nuclear Emergency Response system which consists of the Nuclear Emergency Management Committee(NEMC), KEPCO and MOST. The functions of each are:

1. Nuclear Emergency Management Committee

NEMC, as organized in Fig. 4, is responsible for off-site emergency activities. The role is therefore to plan, develop and promulgate criteria for the emergency response master plan. It also acts to disseminate information to the public.

2. KEPCO

KEPCO is responsible for on-site emergency activities. Its roles are to mitigate the effects of the accident, provide specific emergency measures, handle on-site evacuation and monitor off-site radiological releases.

3. MOST

Minister of MOST is responsible to activate NEMC whenever a nuclear emergency occurs. MOST will also assess, verify and evaluate all incoming data to ensure that adequate information and recommendations are provided to NEMC and that KEPCO carries out the appropriate corrective actions.

A nuclear data network linking NSC and nuclear plants in Korea will be in operation in late 1987. This system is designed to provide the Technical Advisory Team with accurate plant data in the event of accidents as part of the emergency response system.

IV. CONCLUSION

The introduction of nuclear power plants in Korea raises concerns on nuclear power plant safety. Regulation and licensing procedures are in place to assure licensees comply and meet the established nuclear safety standards. Many of ongoing analyses, evaluations, researches and development activities are also in place to

Table 2. Equipment Improvement Plan for KNU-1 & 2

	Mechancal		Electrical		I & C		Total	
	K-1[a]	K-2[b]	K-1	K-2	K-1	K-2	K-1	K-2
Prevention of Trips	13	5	8	4	12	6	33	15
Operation Convenience	15	9	2	2	20	3	37	14
Efficiency Increase	20	3	2	0	1	1	23	4
Reduction of Startup and Incident Recovery Time	3	0	3	0	0	0	6	0
T/S & MOST items	6	0	2	0	5	0	13	0
Reliability Increase	14	19	2	0	1	0	17	9
Safety Increase	14	4	4	0	7	6	25	10
Total (No. of items)	85	30	23	6	46	16	154	52

[a]KNU-1.

[b]KNU-2.

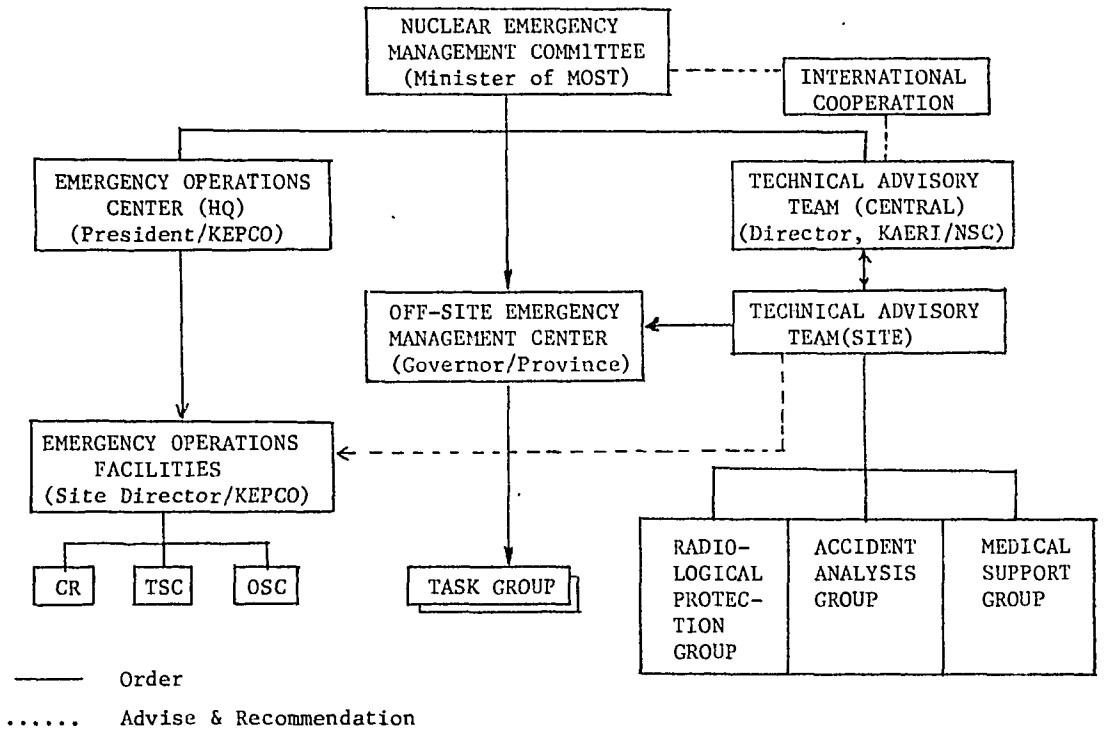

Fig. 4. Organization Structure of NEMC

provide additional information and guidance in the regulatory work.

Currently, Korea depends heavily on foreign nuclear technology. It is expected that as KAERI, KOPEC and other nuclear industries in Korea increase their engineering design capabilities, Korea will eventually become self-reliant and is able to design and build its own nuclear plants starting from KNU-11 and 12.

MOST, together with NSC, requires to improve the regulatory and licensing capabilities, as well as to unify the regulations to meet the Korean regulatory requirements and needs. This should be streamlined with the advancement of capabilities in engineering design.

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