(48%) of the staff are university graduates, 17% having a master degree and 7% having a doctoral degree. SLC itself comprises 183 individuals, 149 of which are technical personnel. CODRE, the unit directly involved with nuclear power plants, has a staff of 42, of which 40 are technical, of which 20 possessing a doctoral or master degree in nuclear science or engineering.

Effective separation between the functions of the regulatory body (CNEN) and the organization responsible for the promotion and utilization of nuclear energy for electricity generation (ELETRONUCLEAR) is provided by the organizational structure of the Brazilian Government itself. While CNEN is subsidiary body of SAE, which is directly linked to the Presidency of the Republic, ELETRONUCLEAR is a part of ELETROBRAS, a national holding company for the electric system, which is subordinated to the Ministry of Mines and Energy (Minstério de Minas e Energia - MME) (see Attachment 1A).

The licensing structure of IBAMA (see Attachment 1D) comprises its Department of Project Evaluation, with a graduated technical staff of 18 professionals and 7 technicians. For the licensing of Angra 2, they work in close cooperation with CNEN staff concerning the radiological impact aspects. They also cooperate with the Rio de Janeiro State Foundation for Environmental Engineering (FEEMA) and the Angra dos Reis Municipal Secretary for Environment.

3.3. Article 9. Responsibility of the licence holder

The Brazilian regulation ascribes to the operating organization the prime responsibility for the safety of a nuclear installation.

ELETRONUCLEAR, as the owner and operator of the Angra plant, has issued a company policy statement regarding its commitment to safe operation, which reads as follows:

> **"Safety is a priority that precedes production and economics. Safety shall never be jeopardized for any reason"**
>
> It further states that:
>
> **"Responsibility for safety is shared equally by the entire corporate structure - Directors, Advisors, Superintendents, Managers and Divisions Heads. Careless acts or actions by employees do not diminish the responsibilities of their supervisors".**

The text of this company policy statement, reproduced in its original Portuguese version in Attachment 2, is fully based on the IAEA INSAG-4 publication on Safety Culture.

The implementation of this policy is based on a programme that adopts the concept of Safety Culture, defines safety objectives and establishes requirements, appropriate management structure (Attachment 1C), resources and self-assessment.

CNEN, through the licensing process, and especially through its regulatory inspection programme, ensures that the regulatory requirements for safe operation are being fulfilled by the licensee. The licensee reports periodically to CNEN in accordance with regulation CNEN-NE-1.14 [7]. In addition, CNEN maintains a group of resident inspectors on the site, who can monitor licensee performance on a daily basis. Finally, a number of regulatory inspections by headquarters staff take place every year, focusing on specific topics or operational events.

Chapter 4. GENERAL SAFETY CONSIDERATIONS

4.1. Article 10. Priority to safety

ELETRONUCLEAR is the product of a merger between the nuclear area of the electric energy utility FURNAS and the nuclear engineering company NUCLEN, both of which had operated for more than 20 years in their fields. Both companies traditionally had policies aiming at giving

priority to nuclear safety.

At the time of the merger, one of the first acts of the new company ELETRONUCLEAR was the approval by the Board of Directors of a document formally establishing the priority attributed by the company to the safety of the installations (Attachment 2). As mentioned above, the safety policy statement establishes that "Safety is a priority that precedes production and economics. Safety shall never be jeopardized for any reason."

To ensure that this policy is being implemented, ELETRONUCLEAR has established a Committee for Nuclear Operation Analysis (CAON), which is responsible for reviewing activities relating to nuclear safety. Furthermore, the Quality Assurance unit (PL), which monitors all design, construction and operation activities, reports directly to the President of ELETRONUCLEAR (see Attachment 1C).

CNEN has also issued a safety policy statement in December 1996, which is equally based on the concept of safety culture.

4.2. Article 11. Financial and human resources

4.2.1. Financial resources

As a governmental enterprise, the financial situation of ELETRONUCLEAR is subordinated to the holding company ELETROBRAS, which controls all federal electric utilities in Brazil. Adequate funds for operation and maintenance of the Angra 1 plant are made available through the annual budget, which includes the plant upgrading programme. Adequate funding for the construction of Angra 2 has also been assured. Funding for the completion of Angra 3 are still under discussion.

In spite of the current privatization of the electric sector, now under way in Brazil, ELETRONUCLEAR will remain part of ELETROBRAS due to the constitutional provisions mentioned in item 1.1 above.

The provision of funds for decommissioning activities is to be obtained from the ratepayers, and is included in the tariff structure, during the same period of depreciation of the plant (5%/year). For Angra 1, a reference decommissioning cost is currently estimated at 111 million dollars, which corresponds to about 10% of the construction cost.

4.2.2. Human resources

Adequate human resources are available for ELETRONUCLEAR from its own personnel or from contractors. Currently ELETRONUCLEAR has a total of 1840 employees in its permanent staff and a long-term contractor which supplies an additional 460 persons on a permanent basis. Of the total 2300 persons, 930 (40%) have a university degree, and 830 (36%) have a technical school certificate.

Activities related to qualification, training and retraining of plant personnel are performed by the Training and Simulator Department of ELETRONUCLEAR, which reports to the Operational Support Superintendent. Three facilities are available for training at the residential village close to the plant: a general training center, a training simulator for Angra 2, and a maintenance training center.

Angra 1 has no plant simulator. Operators for Angra 1 are trained in simulators of similar plants in the USA (Ginna Simulator) or Spain (Tecnatom Simulator). Simulator training load is of at least 60 hours per year for each individual. The composition of control room teams is specified in plant administrative procedures. The minimum control room team comprises a Shift Supervisor (who must hold a current Senior Reactor Operator - SRO licence), a Shift Foreman (also a SRO), a Reactor Operator (who must hold a Reactor Operator - RO licence) and a Balance of Plant Operator (also a RO). Although not required by CNEN, all Angra 1 Shift Supervisors are

graduated engineers with five years of academic education.

The requirements for qualification for the entire Angra 1 staff are set forth in the FSAR pursuant to the principles of Standard ANSI 3.1 issued in 1978. In particular, the Plant Manager, the Deputy Plant Manager, the head of the Operation Department, the head of Technical Support, the Training Manager and the head of the Safety Team are currently licensed SROs or have previously held a SRO licence. The Radiation Protection Supervisor holds a special licence issued by CNEN, according to regulation CNEN-NE-3.03[8].

A full scope simulator for Angra 2 is available for training. Since the beginning of 1985 practical training of Brazilian specialists has been conducted. Instructors from ELETRONUCLEAR have also ministered classroom and practical training for operators, managers and licensing specialists from Germany, Spain, Argentina and Switzerland. With the imminence of the beginning of Angra 2 operation, qualification training for Angra 2 operators is currently under way. The first group of control room operators is scheduled to be licensed in the beginning of 1999.

Specialized training is also provided to the different groups of plant personnel. Maintenance technicians undergo a qualification programme according to their field of activity. Chemistry and radiological protection technicians follow extensive on-the-job training on a yearly basis aimed at a continuous updating of basic concepts learned during their initial technical training. The fire brigade and security personnel are trained according to the requirements established by related CNEN regulations.

Technical visits and reviews of ELETRONUCLEAR's training programme and training center by experts from the International Atomic Energy Agency (IAEA), the Institute for Nuclear Power Operation (INPO) and the World Association of Nuclear Operators (WANO) have provided valuable contribution to the identification and implementation of good practices for enhancing the quality of the training activities.

CNEN monitors the adequacy of the human resources of the licensee through the evaluation of its performance, especially through the analysis of the human factor influence on operational events. The training and retraining programme is also evaluated by CNEN as part of the licensing procedure and through regulatory inspections.

In the specific case of reactor operators, CNEN has established regulations for their authorization [6] and for their medical qualification[9]. CNEN conducts written and practical examinations for Reactor Operators and Senior Reactor Operators before issuing each individual authorization.

4.2.2.1. Technical capability of ELETRONUCLEAR in the design and construction areas

The Brazilian-German Agreement of 1975 provides for the transfer of the technology necessary to the activities of design, equipment manufacture, construction and operation of NPPs to Brazilian companies involved in the nuclear programme. Concerning Angra 2, the German party assumes technical responsibility for the jointly built plant.

For this purpose, several contracts have been signed by NUCLEN (now ELETRONUCLEAR), of which the most important is the Technical Information Contract, which provides for the necessary technology transfer. In the scope of this Contract, the following was accomplished (in round numbers):

- On-the-job training of Brazilian personnel in Germany: 250 engineers (550 man-years);
- German assignees in Brazil: 150 engineers, during the last 20 years;
- Documents transferred: 70.000.

In addition, 22 technology transfer contracts were signed with foreign traditional firms by different private Brazilian component suppliers. This assures a solid and continuous local

technological basis for the design, construction and future operation of the Angra 2 plant and for the support of the operation of Angra 1.

4.3. Article 12. Human factors

Angra 1 was designed at a time when the human factor was not a prime issue in nuclear safety. Following the accident at Three Mile Island, and still before the commencement of operations, a critical review of plant design with respect to the man-machine interface was undertaken. This resulted in numerous modifications in the control room, including the installation of the Angra 1 Integrated Computer System (SICA) which encompasses a safety parameter display system for monitoring critical safety functions. At the same time, plant emergency operating procedures were greatly improved in their format, which now incorporate double columns, the left one dealing with the expected action and the right one with actions to be taken in case of inadequate response.

Later on, the human factor was considered in a much broader sense and several management initiatives were undertaken in this area, such as a programme for team-work training and a Human Performance Enhancement System (HPES). Training in safety culture aspects was also undertaken using IAEA guidelines.

CNEN evaluates the human factor through its assessment of root cause of operational events, through its review of the licensee's training programme, and through the operators licensing process.

Concerning the Angra 2 plant, CNEN has required, during the licensing process, that an additional chapter be included in the FSAR, specially addressing the human factor issue.

4.4. Article 13. Quality assurance

The requirement for a quality assurance programme in any nuclear installation project in Brazil is established in the licensing regulation [4]. Specific requirements for the programmes are established in a specific regulation, Quality Assurance for Nuclear Power Plants, CNEN-NE-1.16 [10], which is based in the IAEA code of practice 50-C-QA Rev.1. Quality Assurance for Nuclear Power Plants, but with the introduction of the concept of an Independent Technical Supervisory Organization (Organização de Supervisão Técnica Independente - OSTI)[11].

Former FURNAS and now ELETRONUCLEAR have established their quality assurance programmes according to these requirements. The corresponding procedures have been developed and are in use. The programme provides for the control of the activities influencing the quality of items and services important to safety. These activities include design, design modifications, procurement, fabrication, handling, shipping, storage, erection, installation, inspection, testing, operation, maintenance, repair, and training.

The Licensing, Environment Management and Quality Assurance Superintendence (PL), reporting directly to the Presidency (P), is responsible for the establishment and supervision of the ELETRONUCLEAR Quality System. A Committee for Nuclear Operation Analysis (CAON) is a collective body under the Operation and Commercialization Directorate (O) with the responsibility of reviewing and analyzing questions related to the operation of the nuclear power plants. A Plant Operation Review Committee (CROU) is a collective body under the Angra 1 Manager (OP1) whose purpose is to examine, follow-up and analyze issues concerning Angra 1 operational safety on closer a basis, and to make recommendations for improving safety.

The ELETRONUCLEAR quality assurance unit is responsible for performing internal and external audits in order to verify compliance with all aspects of the quality assurance programme. All audits are performed in accordance with written procedures. In case of internal audits, the persons involved with the activities being audited have no involvement in the selection of the audit team. Audit reports are distributed to, and formally reviewed by organizations responsible for the area being audited and also by the CAON.

Audits by CNEN ensure that quality assurance requirements are being implemented and that the

quality assurance has been effective as a management tool to ensure safety.

4.5. Article 14. Assessment and verification of safety

A comprehensive safety assessment is a requirement established in the Brazilian licensing regulation.

Concerning the Angra 1 plant, both a Preliminary Safety Analysis Report (PSAR) and a Final safety Analysis Report (FSAR) were prepared in accordance with the requirements of US NRC Regulatory Guide 1.70 - Standard Format and Contents for Safety Analysis Report of LWRs. These reports were reviewed and assessed by CNEN, and in the case of the FSAR, extensive use was made of the US NRC - Standard Review Plan (NUREG - 0800).

The safety assessment included both deterministic and probabilistic approach to safety analysis. The deterministic approach followed the traditional western methodology using complex computer codes for the analysis of a large number of postulated events, ranging from minor transients to a large loss of coolant accident (LOCA). The probabilistic approach used probabilistic safety assessment (PSA) methodology. Although a full PSA was not a formal licensing requirement, a preliminary study was performed in 1983 using generic plant data. A new study is being developed, using plant specific reliability data, and more modern PSA methodology, and covering additional scenarios such as external events, fires and floodings.

Safety analysis report data are verified through the system of regulatory inspection, extensive commissioning test programme, and through the normal operational surveillance programme of the operator.

Concerning the Angra 2 plant, a larger amount of information was provided, but still a FSAR following the US NRC Regulatory Guide 1.70 format is being requested for the operation licence review. ELETRONUCLEAR is also planning to conduct a PSA for Angra 2.

4.6. Article 15. Radiation protection

Radiation protection requirements and dose limits are established in Brazil in the regulation for radiation protection[12]. These require that doses to which the public and the workers are exposed be kept below established limits and as low as reasonably achievable (ALARA).

Implementation of this regulation is performed by the basic plant design and through the establishment of a Health Physics Programme at each installation. Plant design is assessed at the time of the licensing review and by evaluating the dose records during normal operation.

The Health Physics Programme of Angra 1, included in the Final Safety Analysis Report, sets forth the philosophy and basic policy for radiation protection during operation. The highest level policy is to maintain personnel radiation exposure below the limits established by CNEN and to keep exposures to as low as reasonably achievable (ALARA), based on technical and economical considerations.

The annual exposure of workers is limited to a dose of 50 mSv for the effective dose equivalent, and 500 mSv for dose equivalent for individual organs and tissues, except in the case of the eye lens, the limit of which is 150 mSv. For women of reproductive capacity, the exposure is limited to a dose of 10 mSv for any quarter of the year, and, should they become pregnant, the limit is reduced to 1mSv for the extent of the pregnancy. These limits are in accordance with CNEN regulations, with applicable labor legislation that has endorsed CNEN limits, and with the international Convention n. 115 of the International Labor Organization (ILO), ratified by Brazil.

Release of radioactive material to the environment is controlled and kept below CNEN and IBAMA established limits, in accordance with administrative procedures. Additionally, the amount of radioactive waste and the radioactive effluents discharged into the environment also follow the ALARA principle.

A plant ALARA Commission composed of different groups (Operation, Maintenance, Chemistry, System Engineering and Radiation Protection) is in charge of implementing and monitoring the ALARA Programme that describes procedures, methodologies, processes, tools and steps to be taken in planning the work. The ALARA Programme has been continuously revised and represents the best effort to minimize occupational doses.

A Radiological Environmental Monitoring Programme, based on CNEN requirements, is conducted by ELETRONUCLEAR to evaluate the possible impact caused by the plant operation. This programme defines the frequency, places, types of samples and types of analyses for the survey of exposure rates. The evaluation of exposure rates is also made by direct measurement using thermoluminescent dosimeters distributed in cardinal sectors around the Angra site, and at points located in the nearest villages and cities. The results of the monitoring programme are compared with the pre- operational measurements taken, in order to evaluate any possible environmental impact. Semi- annual reports are presented to CNEN. To date no major environmental impact has been detected.

4.7. Article 16. Emergency preparedness

Brazil has established an extensive structure for emergency preparedness under the so- called System for Protection of the Brazilian Nuclear Programme (SIPRON). This includes organizations at the federal, state and municipal level involved with licensing and control activities as well as those organizations involved with public safety and civil defense. Operators of nuclear installations and facilities and supporting organizations are also part of SIPRON.

SIPRON was established by Law n. 1809 of October 7 1980. The Decree n. 2210 of April 22 1997 established the Secretary for Strategic Affairs (SAE), directly linked to the Presidency, as the central organization of SIPRON. This decree also establishes a Coordination Commission (COPRON) composed of representatives of several governmental agencies involved. Besides ELETRONUCLEAR, as the operator, and CNEN, as the nuclear regulatory body, other agencies are involved as support organizations, such as the municipal civil defense, the state civil defense, the Angra Municipality, the IBAMA, the National Road Department (DNER), the National Army, Navy and Air Force, and the Ministries of Health, External Relations, Justice, Finance, Planning and Budget, Transportation, and Communications (see Attachment 1E).

Within SIPRON, SAE issued a General Norm for Emergency Response Planning (SIPRON- NG-02)[13] and has prepared specific guidelines for Angra site emergency planning (Diretriz Angra 1) [14], consolidating all requirements of related national laws and regulations and stating the responsibilities of each of the involved organizations. Additional norms related to emergency centers, communications, and information to the public were also issued by SAE.

At the plant level, a comprehensive Emergency Plan has been established and is periodically tested. The plan involves several levels of activation, from single alert status, through area emergency, to a general emergency. Dedicated facilities at the plant site and in the local region have been designated and, with the assistance of the licensee, the local civil defense equipment for emergencies has been greatly upgraded.

Corresponding plans for CNEN, its support Institute for Radiation Protection and Dosimetry (IRD) and other involved agencies have been prepared, and detailed procedures have been developed and are being revised.

The presence of more than 7000 workers at the Angra site, due to the construction of Angra 2, has created a peculiar temporary situation that hampers immediate emergency response.

In 1996, after a review of the existing plans and comparing with information obtained during the observation of an emergency exercise in the United States by a SIPRON working group, substantial changes were introduced in the emergency response approach. After these modifications were introduced, in 1997, SAE coordinated two partial exercises and a general emergency exercise. The general emergency exercise established 20 objectives to be demonstrated

and evaluated to verify and validate the adopted systematic approach. The exercise was observed by international experts from the IAEA and Argentina, who prepared a report [15] which concluded that the exercise achieved most of its objectives.

Regarding information to the public, SIPRON norm NG-05[16] establishes the requirements for public information campaigns about emergency plans. The first public information campaign was conducted by FURNAS in 1982 before the first criticality of Angra 1 was attained. Several other campaigns have been conducted. The last campaign in 1997 combined information on both on-site and off-site emergency plans, including the population living in the 15-km area around the plant. This campaign included the distribution of informative material on a house-to-house basis, to local newspaper, radio, TV, buses and bus stations, schools, community association, churches, and administrative offices. These campaigns are conducted by personnel from the federal, state and municipal civil defense, state fire brigade, ELETRONUCLEAR volunteers, and CNEN and ELETRONUCLEAR technical and public information personnel. Preceding every siren test or a general emergency exercise, specific flyers are distributed in affected areas and handed along main routes to passing drivers and buses, and vehicles fitted with loudspeakers circulate through villages making announcements to ensure that all residents have been properly informed.

It should be noted that, due to the particular geographical situation of the Angra plant, no radiological impact is likely to occur in any neighboring countries, even in the improbable event of a major release. Notwithstanding that fact, Brazil has signed both the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in Case of a Nuclear Accident or Radiological Emergency, and a bilateral agreement with Argentina for notification and assistance in case of a nuclear accident.

Chapter 5 - SAFETY OF INSTALLATIONS

5.1. Article 17. Siting

The Brazilian siting regulation CNEN 09/69[5] requires a site approval before the issuance of a construction authorization. The Angra site has already been approved for the 3 units. Site parameters are further evaluated during the PSAR preparation and review and are taken into consideration in the plant design.

For the Angra 1 plant, whose construction began in 1972, the environmental impact was not formally evaluated before site approval, since no related regulations existed at the time. The environmental impact was assessed at the time of the operating licence by FEEMA as described in 3.1. above.

Since the promulgation of Law 6938 of August 31 1981, which establishes the National Policy on the Environment (PNMA), "the construction, installation, expansion and operation of facilities or activities which cause or may cause pollution or are capable of causing environmental degradation" requires an environmental licence. This involves the elaboration of an Environmental Impact Study (EIA) and the preparation of an Environmental Impact Report (RIMA) before site approval. Considering that the site of Angra nuclear power plant was already in use for a nuclear unit, the environmental licensing of Angra 2 included the preparation of an EIA/RIMA only for the operation licence. These documents are currently being reviewed by IBAMA in cooperation with CNEN. The RIMA will constitute the main document to be discussed during the public hearings scheduled for the end of 1998, within the environmental licensing process.

With respect to Angra 1, site parameters continue to be evaluated during plant operation, especially those related to the demographic distribution with respect to emergency preparedness. An updating of the detailed population census in the vicinity (5-km radius) of the power plant was conducted in 1996.

5.2. Article 18. Design and construction

The design of the Brazilian nuclear power plants is based on established nuclear technology in