April 3, 1996

MEMORANDUM TO: Gary M. Holahan, Director
Division of Systems Safety and Analysis

THRU: Robert C. Jones, Chief
Reactor Systems Branch
Division of Systems Safety and Analysis

Timothy E. Collins, Chief
Advanced Reactor Systems and Special Projects Section
Reactor Systems Branch
Division of Systems Safety and Analysis

FROM: Alan E. Levin, Sr. Reactor Engineer
Special Projects and Advanced Reactor Systems Section
Reactor Systems Branch
Division of Systems Safety and Analysis

SUBJECT: TRIP TO SWITZERLAND, ITALY, AND THE NETHERLANDS,
MARCH 5-13, 1996

I traveled to the Paul Scherrer Institute (PSI), in Wuerenlingen, Switzerland on March 6-8; to Ansaldo Nuclear Division in Genoa, Italy, on March 11; and to the Dodewaard nuclear power station near the village of Dodewaard in The Netherlands on March 13. The purposes of these three visits were:

PSI: Participate in quality assurance (QA) inspection and technical discussions on the PANDA test program, conducted as part of the SBWR design certification testing program;

Ansaldo: Discuss QA procedures and interfaces between Ansaldo and the U.S. vendors related to the design certification test programs for the AP600 and SBWR; specifically, the AP600 VAPORE program at ENEA's CRE/Casaccia Laboratories, and the SBWR PANTHERS program at SIET Laboratories;

Dodewaard: Discuss in-plant testing related to natural circulation BWR stability that has been conducted over the last several years at the Dodewaard plant.

This report discusses the meetings that were conducted during each of the three visits. A separate report on the PANDA QA inspection is being prepared by the QA inspection team leader; however, some elements of the QA inspection are also discussed in this report. The only material received during these meetings were copies of slides used to make presentations to NRC staff; these are included as Attachment 1. Attachment 2 lists the personnel contacted at each meeting site.

DF03 //
OJM-15-1
X-IA-1-4-Italy

PANDA QA Inspection and Technical Discussions at PSI, March 6-8, 1996

On March 6-8, I reviewed material related to design control in the PANDA test files at PSI as part of the QA inspection on the PANDA program. I also participated in two technical meetings to discuss test results and technical issues related to application of PANDA results to SBWR safety analysis. In addition, since this was my first visit to PSI, I was given a brief tour of the PANDA facility.

The design control portion of the PANDA test files appeared to be complete and well-documented. One significant item that I found in the files was a memorandum recording the results of a formal design review of the PANDA facility and test program, which was conducted by GE at San Jose in October 1991. The design review team made a number of important recommendations and assigned action items for follow-up. At the time the design review memorandum was written, GE was maintaining that the PANDA test program was "confirmatory," and should not be required for SBWR design certification. In addition, the memorandum was written almost two years before the NRC began its inspections of test program QA implementation. However, prominent among the recommendations of the design review team were development of a formal QA program for PANDA, at least in part to help ensure NRC acceptance of the results. Other recommendations included: (1) performance of a scaling analysis; (2) use of data for TRACG qualification; (3) additional instrumentation; (4) consideration of tests to simulate hydrogen behavior in the containment; and (5) computational fluid dynamics analyses to aid in evaluating mixing behavior in the drywell. PSI was also asked to evaluate the possibility of density-wave oscillations in the PCCS and isolation condenser (IC) HXs. On the basis of the memorandum, and contrary to GE's stated position at the time, it appears that GE recognized the need for the PANDA data as part of the design certification database, and further, that GE recognized the need for implementation of proper QA procedures as part of the development of the test program.

There was no record in PSI's files as to whether the action items in the memorandum were, in fact, resolved; we were informed that any such record would be in GE's files at San Jose, since that was where the initial memo originated, and where the complete PANDA DRF resides. It is an open question as to why these recommendations were apparently not implemented at the time, especially since some of these issues developed into major sticking points between the NRC and GE between 1992 and 1994. (For instance, development of a QA program was supposed to be completed within about 6 months of issuance of the design review memorandum.) It is also worth noting that this memorandum is, in a sense, consistent with documentation we have discovered in other SBWR testing files. For instance, during the trip to Toshiba in August 1994, we found a letter in the GIRAFFE files, dating back to the early days of that program, which GE sent to all of its international technical associates (ITAs), requesting details on their QA programs in order to document compliance with NQA-1 per GE's commitment to the Department of Energy. Based on available evidence, it appears that GE anticipated very well many of the technical and administrative issues that later arose on the SBWR test programs, but did not act on those issues until much later, at the NRC's request.

On March 7-8, I participated, with other NRC staff members, in technical discussions on the PANDA program with PSI and GE representatives. PANDA is a low-pressure facility that provides essentially a full-height representation of the SBWR at 1:25 volume scale. I found it to be physically quite impressive; it represents the largest-scale thermal-hydraulic test facility being used for passive plant testing, by both the vendors and the NRC (the ROSA/LSTF facility being used for AP600 confirmatory testing is approximately 1:30 volume scale). Transient tests in PANDA were generally initiated under conditions equivalent (scaled) to those in the SBWR approximately one hour after a main steamline break, and were designed to provide data chiefly on containment behavior during long-term post-accident cooling.

PSI went through a detailed description of each transient test performed in the facility as part of the SBWR testing program, highlighting important phenomena and system behavior. Significant technical issues covered in these discussions included: vacuum breaker operation; drywell pressure response; ability of PCCS to remove decay heat and operation of main LOCA vents from drywell to wetwell; and, to some extent, use of PANDA data for TRACG modeling. Of particular interest was one test, M7, in which the main LOCA vents oscillated open and closed over a period of several hours. Direct communication between the drywell and wetwell through the LOCA vents bypasses heat removal in the PCCS, and contributes to increased containment pressure, since there is no safety-related heat removal system for the suppression pool. GE and PSI asserted that the oscillatory behavior was similar to that observed during earlier steady-state tests, and resulted from fluctuations in water level and steam production in the PANDA pressure vessel that were related to the facility design and would not be observed in the SBWR. Also of interest from the reactor systems standpoint was the single test in PANDA (M9) for which the nominal starting time was approximately 19 minutes after accident inception, rather than one hour. Emergency core coolant injection from the gravity drain cooling system (GDCS) was simulated in M9, and conditions overlapped, to a degree, those simulated in the GIRAFFE Systems Interaction Tests (SIT), although the GIRAFFE/SIT tests represented other break scenarios.

All of the tests in GE's PANDA test matrix have been performed, with one exception: a test was originally specified that would involve actuation of drywell sprays, which would tend to encourage actuation of the vacuum breakers. GE's primary objective in these discussions was to get the NRC's agreement that the PANDA testing performed to date fulfills the objectives set out in the Test and Analysis Program Description (TAPD), and that no further testing needs to be done. The rationale for this position is that a significant number of vacuum breaker actuations were observed in other tests and, further, that GE has removed containment spray phenomena as "high-ranked" items in the SBWR phenomena identification and ranking tables (PIRTs). Unfortunately, GE has not yet provided sufficient data for the NRC staff to review for a determination to be made as to the adequacy of the test program to fulfill the TAPD objectives.

Based on a necessarily superficial evaluation, it appears that the PANDA program has generated a substantial amount of valuable data for TRACG validation related to the SBWR. In addition, based on review of the material presented and comparison to the GIRAFFE/SIT test that I observed at Toshiba in October 1995, it appears that PANDA's response is consistent with that observed in GIRAFFE (accounting for the differences in facility configuration and break scenario). With the recent decision of GE to withdraw the SBWR from the design certification process, however, it is not clear that the NRC staff will be able to do a detailed review of the test data and reach any conclusions on the adequacy of the test program. A final observation is related to the way in which the SBWR test program has been conducted by GE's ITAs. It is clear that GE is dependent upon the technical expertise of the ITA organizations to assist in analyzing the test data and understanding the phenomena that are observed in the experiments. For instance, the technical discussions on PANDA were led by Professor Yadigaroglu of PSI. This is in contrast to the approach taken by Westinghouse in the AP600 testing program, in which the testing organizations are involved to a lesser extent in data analysis. Thus, discussions on SBWR testing <u>must</u> involve members of the testing organization in order to gain a detailed understanding of the experimental results.

<u>Meeting at Ansaldo Nuclear Division, March 11, 1996</u>

I participated in discussions as part of an NRC group at Ansaldo's offices in Genoa on March 11. The purpose of the visit was to discuss Ansaldo's QA program, and in particular, how the QA program was implemented for Ansaldo's activities as part of the passive plant test programs. Ansaldo has had a major role in both passive reactor testing and analysis programs. Ansaldo was ENEA's prime contractor for modification of the VAPORE facility at the Casaccia Laboratories, which was used for automatic depressurization system testing for the AP600. In addition, Ansaldo performed pre-test calculations, under contract to Westinghouse, for the AP600 tests performed in the SPES-2 facility at SIET Laboratories. For the SBWR, Ansaldo designed and fabricated the PCCS and IC prototype heat exchangers tested in the PANTHERS facility at SIET Laboratories. The tests were conducted under the supervision of GE and ENEA. Both of these heat exchangers leaked during testing: the PCCS HX leaked during thermal-hydraulic performance tests, and the IC HX leaked during structural-related tests, after completion of the thermal-hydraulic performance phase of testing. Both of these components have "zero leakage" as a performance criterion, and Ansaldo is assisting GE in post-test evaluation of component performance, investigating the reasons the leaks occurred and what steps may be required to correct the problems.

Beyond the design certification test programs, Ansaldo is also involved in ADS valve qualification testing at VAPORE. Although the same facility is used as in the thermal-hydraulic tests, the objective of the qualification testing is different from the design certification tests, and is considered by Westinghouse to be part of the first-of-a-kind engineering (FOAKE) effort.

Both Westinghouse and GE committed to implement an NQA-1 QA program for design certification testing; this commitment extended to contractors and partners.

Ansaldo is a large, multinational company; although it began as a private company, it now is under state control as part of the Finmeccanica Group. Although all of Italy's nuclear power plants have been shut down, Ansaldo's nuclear-related operations have remained active in developmental activities; aside from involvement in the U.S. vendors' passive plant programs, the company also participates in development of the European Passive Plant (EPP) and the Italian "ISIS" concept, an "inherently safe" design. Other nuclear-related projects have included work on the Cernavoda (CANDU) plant in Romania, the Superphenix liquid-metal fast breeder reactor in France, and various VVER designs in Russia and elsewhere in Eastern Europe. The total staff of the Nuclear Division (which does not include the components fabrication operation) numbers 212.

As a major industrial company that has been involved in nuclear design and construction, the Ansaldo Nuclear Division has a well-developed QA program and organization. The Ansaldo QA manual was originally developed based on the structure of the NQA-1 standard, since it predates the development of the European ISO-9001 QA standard. The QA manual now incorporates elements of NQA-1, IAEA 50-C-QA, and ISO-9001. (Ansaldo is currently in the process of obtaining ISO-9001 QA certification.) However, we also learned that, for projects in which Ansaldo is a contractor to another company, the QA requirements are specified in the contract by Ansaldo's customer, so that implementation depends upon the contractual specifications.

Ansaldo Nuclear Division has been audited by both GE and Westinghouse as a contractor for the passive plant programs. Two GE audits resulted in no findings. Three Westinghouse audits have been performed. In 1991 and 1993, a total of 4 non-conformances and 7 observations were noted; however, no findings were indicated in the most recent audit (October 1995). Ansaldo Componenti (formerly ACO, now called UCN), the components fabrication operation in Milan, is a separate organization from the Nuclear Division. UCN holds an "N" stamp certification from the ASME, for which the most recent survey was conducted in 1995.

Our general discussion on Ansaldo's QA program was followed by separate discussions with each vendor and the corresponding Ansaldo personnel. For Westinghouse, we initially focused on the VAPORE facility modification that was performed between the ADS Phase A (sparger) and Phase B1 (valve/piping network) test programs. The work done for Westinghouse on the VAPORE facility was undertaken as part of a three-party agreement between ENEA, Westinghouse, and Ansaldo. The contracts for the work on VAPORE for Phases A and B1 were drawn between Ansaldo and ENEA (rather than Westinghouse). Thus, ENEA was responsible for specifying QA requirements to Ansaldo. According to Ansaldo, no specific QA requirements were included in these contracts; rather, "best engineering practice" was specified. This is consistent with what we found in our initial visit to Casaccia in October 1994, in that ENEA had no formal NQA-1 program. However, the facility modifications were carried out in accordance with Italian law for high-pressure (non-nuclear) facilities, which we were told is essentially equivalent to the requirements in the applicable parts of the ASME Boiler and Pressure Vessel Code. Irrespective of the fact that no specific requirements were imposed by ENEA on Ansaldo, the Ansaldo QA program was implemented for its VAPORE activities.

Ansaldo Nuclear Division designed the VAPORE modifications. However, the fabrication and field assembly operations were subcontracted to Caldararia-Carpenteria-Meccanica (CCM) and Quadraccia, respectively. Both of these companies are on Ansaldo's approved supplier list, and are audited by Ansaldo. Ansaldo was also responsible for instrumentation procurement and initial field calibration.

CCM and Quadraccia developed detailed fabrication drawings based on Ansaldo's design drawings. As-built drawings were then developed from the shop fabrication drawings. However, as we learned during the VAPORE QA inspection in July 1995, field measurements were not taken to verify the as-built dimensions (which resulted in a non-conformance, as reported in "NRC Inspection No. 99900404/95-02," letter, Gallo to Liparulo, October 6, 1995). This apparently resulted from a miscommunication between Westinghouse and Ansaldo; Westinghouse acknowledged that specifications to Ansaldo should have indicated that field measurements were required to verify as-built dimensions.

We did not discuss in detail the FOAKE activities conducted at VAPORE after the completion of design certification testing. However, we were told that this was a contract directly between Westinghouse and Ansaldo, specifying the QA requirements for the program. We were also told that any future activities involving Ansaldo would be carried out under the Ansaldo QA program.

We also discussed briefly the QA program that Ansaldo implements for analytical work, such as that conducted for Westinghouse on SPES-2. Ansaldo appears to have a well-developed set of QA controls and requirements for analytical activities, including maintenance of a design record file related to the code calculations. Since these activities were not a direct part of the design certification, we did not review documentation related to these calculations as part of the SPES-2 QA inspection (October 1994).

The arrangement under which Ansaldo participated in the SBWR program is considerably different from that for the AP600. Ansaldo is part of a four-party agreement on the SBWR, which also involves ENEA, GE, and ENEL (state-owned utility). The PANTHERS program was arranged under an ENEL contract to Ansaldo, with Ansaldo then contracting to ENEA and ENEA contracting to SIET (which is owned by ENEA and ENEL, among others). Ansaldo Nuclear Division was the designer of the heat exchangers tested in PANTHERS and Ansaldo Componenti (ACO) was the subcontractor to the Nuclear Division that fabricated the components. Ansaldo Nuclear Division provided QA oversight at ACO, through a resident engineer at the fabrication facility.

The IC and PCCS HXs tested in PANTHERS are not N-stamped components. We were told that the installation of instrumentation in the HXs required processes that are not acceptable for an N-stamped article.

Installation of the HXs in the PANTHERS facility was also done by Ansaldo. However, SIET was responsible completely for preparation of the test facility, i.e., everything in PANTHERS except for the HXs themselves.

We also attempted to discuss in some detail the problems with leakage that were encountered during the testing programs. GE's position was that the causes for the leakage are still under investigation, but that the amount of leakage during the PCCS thermal-hydraulic tests was so small as not to affect the results of the tests themselves. (As previously stated, the IC leakage occurred after the completion of the thermal-hydraulic performance phase of that test program.) The investigation is being conducted by GE, Ansaldo, and ENEA, with support from SIET. Once the reasons for the leakage are determined, design fixes will be evaluated. As a result, GE has been reluctant to discuss this issue until the investigations have been completed.

We did learn that both HXs were hydrostatically tested after initial installation in the PANTHERS facility and were found to be leak-tight. In response to a question, we were also told that a formal non-conformance report had not been issued regarding the HX leaks, although the leakage would appear to constitute a non-conformance with respect to the zero-leakage performance criterion established for these components.

Meeting at Dodewaard Nuclear Power Plant, March 13, 1996

I participated in a meeting with representatives from NV Gemeenschappelijke Kernenergiecentrale Nederland (GKN), the utility that operates Dodewaard; the Dutch Nuclear Safety (regulatory) Department (KFD); and the Delft University of Technology (TUD). The meeting was arranged by Mr. George Vayssier, of the KFD, at my request, after GE declined to participate. The main purpose of the meeting was to discuss experiments performed in Dodewaard to investigate issues related to natural circulation BWR stability. GKN performed the experiments and is publishing the data in reports. Dr. T. H. J. J. van der Hagen, of TUD, is involved with the preparation of the reports, as well as with the evaluation of the test data. He attended the meeting and gave a presentation on his analysis of the data. Other participants included Mr. Karuza and Mr. Nissen of GKN, and Mr. Hoekstra, the Dodewaard plant manager. I had also requested that Mr. Vayssier extend invitations to the meeting to KEMA, an engineering consulting company that works with GKN, and ECN, the Dutch "national laboratory" for energy research, which has worked with GE on SBWR-related analysis; however, neither of those organizations participated in the meeting. This was my second trip to Dodewaard; I first visited the plant in 1993, as a member of a group led by then-NRR Director Dr. Thomas Murley.

Issues related to plant stability were among the topics discussed during the first visit, but the test program was not covered in detail. Before I left on this trip, I met with members of the Reactor Systems Branch BWR Systems

Section and DSSA Analytical Support Group to discuss issues concerning stability that I should cover in the Dodewaard meeting.

I began the meeting with a short, informal discussion of the NRC's activities related to design certification of the passive designs; I also relayed the news of GE's decision, made public in early March, to withdraw the SBWR 670 MWe design from the design certification process. We then proceeded to a lengthy discussion and presentations on the Dodewaard stability experiments. GE cites, in the TAPD, data taken during a Dodewaard startup in February 1992 to support claims that the SBWR would be stable during startup. However, during our review of the TAPD, we became aware of additional experiments that had been performed during startup of the plant in 1994, in which some oscillations, referred to as "resonances" had been observed at very low power and low pressure. Just before departing for the trip, I was also sent a brief report on recently-acquired data from a test during a plant shutdown, at higher pressures and powers, which culminated in a unstable oscillations and a plant scram due to high neutron flux.

Dodewaard is a small (approximately 60 MWe) natural circulation BWR, which has been in commercial operation since the beginning of 1969. It is essentially a "twin" of the Humboldt Bay plant in the U.S., which was shut down about 20 years ago. The concept is basically the same as the SBWR, but the plant differs considerably in design from the SBWR. Dodewaard employs active safety systems, rather than the passive SBWR systems, and the primary system design details are different as well: the core is shorter, and the fuel pins are larger and more widely spaced than in the SBWR. The chimney is also shorter than the SBWR, and--perhaps most distinctive--Dodewaard uses free surface separation (no hardware), in contrast to the separator/dryer components in the SBWR. The differences in core design and the approach to steam separation both have an effect on reactor stability, as will be discussed further below. Of particular note is the fact that Dodewaard employs a stability monitoring system, with a meter in the control room. The meter displays the decay ratio, based on a 16-second moving average of instrument data. Dodewaard operational limits are based on the decay ratio as calculated by this system; the "action value" for decay ratio is 0.6.

The first presentation was given by Mr. Nissen, of GKN. He explained that, from the beginning, Dodewaard has been employed as a test facility as well as a power production facility. Testing has been conducted over the entire 27+ years that the plant has been in operation. However, the testing that was done early in the plant's life was apparently not done according to any real "plan." In 1990, however, a decision was made to cover issues by testing in a more "systematic" manner, with more care taken in defining test conditions, standardizing the experimental and analytical tools, and evaluating experimental uncertainties. The general purposes of the tests are (1) to allow better understanding of plant stability characteristics, and (2) to determine if there <u>are</u>, in fact, stability concerns requiring action. The data are used for a variety of purposes, including in-house development and improvement of safety analysis; improved fuel management, and simulator development. The data are also used by organizations that work with GKN, such as KEMA and ECN, for code development and validation. For example, ECN uses the RELAP code for Dodewaard calculations. Further, in 1992 Dodewaard was required to go through a relicensing process due to legal problems with a previous licensing procedure. Data from the plant tests were used to support the relicensing effort, which has recently been completed successfully. Associated with that effort, the plant has been undergoing--and will continue to implement--a series of modifications and upgrades to plant and safety systems, which will extend through 1997.

A very important aspect of the test program is that GKN does not consider the data to be "proprietary," and is committed to getting the data reports into the public domain "for anyone who wants to use it." (Note: the data reports do not include any substantial analysis or evaluation.) To date, six reports have been completed and five are either available or in the final stages of publication. The reports cover tests under the following conditions: normal operation; transients; startups; shutdowns; and different temperatures and pressures.

Mr. Nissen reviewed the normal startup procedure used at Dodewaard. This was also covered during our meeting in 1993. Dodewaard starts up over a period of about 2-3 days. The initial part of the procedure, which includes first heating to saturation temperature at atmospheric pressure, increasing power slowly to about 1%, then gradually increasing pressure to operating levels and power to about 30% in approximately 7 hours, is followed to ensure remaining within thermal-hydraulically stable conditions. After the power has been raised to about 70-80%, the rate of power increase is also reduced, due to limitations resulting from pellet-clad interactions. Over the course of the startup, data are taken approximately every two hours. The instrumentation used is that normally available in the plant: basic instrumentation recorded by the plant data logger; self-powered neutron detectors; and thermocouples in the downcomer. The stability monitor is used to determine decay ratio during the tests. Particular attention is also paid to noise measurements using neutron detectors.

Startup data has been acquired over a range of conditions, from atmospheric pressure to normal operating conditions. In general, the plant has demonstrated excellent stability over the entire range of test conditions; Mr. Nissen indicated that there were times when the decay ratio was so low (indicative of highly stable conditions) that it was difficult to get a reading from the stability meter. The tests also have shown that recirculation flow is established very rapidly in Dodewaard, contributing to plant stability, with measurable downcomer flow at about 5 bars (approximately 73 psi) and substantial in-core velocities (estimated at 0.7 m/s, or about 2.3 ft/s) at a pressure of 10 bars (about 145 psi). Additional tests are currently being planned, with the objective of acquiring data at less stable conditions. Two means for accomplishing this are to try to "induce" less stable conditions by operating at increased power at lower temperature, and by taking additional data at low pressures and low powers, under conditions where the plant may actually be in a region of reduced stability. This will be explained further below. It is not clear when these tests may be done; the modifications now underway on the plant may require periods of plant shutdown or extension of planned shutdowns, and could thereby impact the schedule for additional tests.

After Mr. Nissen's presentation, Dr. van der Hagen gave a presentation about the startup tests conducted in 1994. He began by discussing the characteristics of oscillations in BWR systems and the specific features of Dodewaard that bear upon its stability. Type I oscillations are those that occur due to thermal-hydraulic factors alone, while Type II oscillations involve both thermal-hydraulics and neutronics. Both types of oscillations are affected by core design parameters, including pin spacing and diameter. Dodewaard's open core design (wide spacing) tends to promote stability. In addition, the large fuel pins in the plant tend to respond slowly to changing conditions (long time constant), and have a damping effect on oscillations. Another aspect of Dodewaard that affects stability, in a more complex fashion, is its dependence on free-surface separation. The lack of steam separation hardware means that Dodewaard loses a significant fraction of its steam production--about 20%--to "carryunder," wherein the steam is entrained in the fluid that flows back to the downcomer. This also adds energy to the downcomer fluid as the voids collapse, and affects downcomer subcooling, which in turn can affect stability.

The 1994 startup tests were conducted under low-pressure (about 2-5 bars), low-power (about 5%) conditions. Rather than going through a normal startup, in which this power/pressure region would be traversed relatively quickly, the plant was held at these conditions, and pressure and power were changed slightly to see if oscillations could be induced. When oscillations were observed, the system was either in single phase flow or in low-quality two-phase flow. Flow behavior, and associated stability characteristics, was derived by analysis of neutron noise measurements. Several different oscillations were discovered when the noise signals were analyzed. At the lowest power, a "low-grade" oscillation with a period of about two minutes was observed, corresponding to the time it takes the coolant to make a full circuit of the system (reactor to turbine and back to the reactor). As the power was raised, the period of the oscillations became shorter, indicating a change in character. At the highest power, and at a pressure of 4.5 bars, an undamped "limit cycle" oscillation was observed, with an amplitude of about 6% peak-to-peak. The period of this oscillation corresponded approximately to the time it takes the coolant to flow through the core and the chimney, and the characteristics of the oscillation are similar in some respects to "classic" density waves. These are considered to be Type I oscillations, with essentially no neutronic feedback.

I asked whether these types of oscillations would be seen during a "normal" startup, and whether there was any safety concern. GKN indicated that the plant operators were trained about stability, and about what to do if these types of oscillations were observed; the immediate remedy would be to raise the power, which stabilizes Type I oscillations. GKN also clearly stated that these types of oscillations would likely not be seen during a normal startup, but that if they were, there was no safety concern due to the low power and quality, the small amplitude, and the apparently self-limiting character of the oscillations. The simple analysis that Dr. van der Hagen presented of this type of oscillation indicates that there is a very small region as the system goes from single-phase to two-phase conditions in which the decay ratio is always greater than unity, indicating an unstable condition. However, the region is so narrow, and the normal "traverse" of the region is so rapid in a normal startup, that sustained instabilities never have the chance to develop.

Following this presentation, we discussed the most recent tests, conducted during a planned reactor shutdown. The plant was held at reduced pressures, 33 bars and 45 bars (normal operating pressure is about 70 bars), and around 70-80% power, to see whether instabilities would develop. These tests were reviewed by the KFD, based on pre-test calculations provided by GKN. The stability meter was used to monitor the decay ratio of the system; the maximum decay ratio predicted was about 0.8. At a pressure of 33 bars and a power of 140 MWt (about 80%), the stability meter indicated a decay ratio of about 0.8-0.85. Plant personnel were attempting to take measurements when a system-wide oscillation occurred which increased in amplitude (indicating a decay ratio greater than 1), and ultimately caused the reactor to scram on high neutron flux (about 115%). The reasons for the growing instability are unclear, but they may have been triggered by a power change earlier in the test.

At this time, GKN, KFD, and TUD are evaluating the test, and trying to understand why the system behaved as it did. The data taken before the scram shows several periods where the plant appeared to be growing more unstable, with oscillations of increasing amplitude; however, these oscillations then decreased before reaching the scram setpoint. It appears that the system's decay ratio was fluctuating during these periods, but with a 16-second averaging time for the stability meter, these fluctuations may not have been detected. Dr. van der Hagen also stated that above a decay ratio of about 0.6, it may not be "useful" to think in terms of decay ratio. He believes that small perturbations in system conditions may cause the decay ratio, at values greater than about 0.6, to change very rapidly, potentially increasing above unity (unstable system). In addition, Dr. van der Hagen stated that the algorithm used for the Dodewaard stability meter is based on linear stability analysis, but that at high decay ratios, non-linear effects may begin to play a significant role in system behavior, which would affect the capability of the meter to reflect accurately the system's condition. It was clear that at this point, there is still not a good understanding of the reasons for the plant's behavior up to the time of the last cycle of oscillations, and analysis of the data is continuing.

One item that came up in discussion of these tests was that Dodewaard apparently does not have any requirements in the plant technical specifications that prevent operation under the conditions immediately prior to the time at which the unstable oscillations occurred. Originally, Dodewaard's operational limits were based on a maximum allowable outlet void fraction of 70%. This value was based on stability concerns, but was characterized as a "best guess," conservative value provided by GE. When the stability monitoring system was installed, this limit was replaced by one based on the indications of the stabilit, meter (decay ratio less than 0.6), and operation at void fractions above 70% was permitted. Just before the system went "unstable," the indicated decay ratio was less than 0.6, fulfilling plant requirements; however, as discussed above, small perturbations in the plant's condition apparently drove the system rapidly to a decay ratio greater than unity. While it is clear that the plant would never be operated at this combination of reduced pressure and relatively high power under normal situations, both GKN and KFD have expressed some concern about the lack of explicit guidance preventing operation near conditions that could become unstable, and GKN is considering establishing additional controls on plant operation to provide such guidance.

I also asked about the application of Dodewaard result to the SBWR. Dr. van der Hagen did not want to speculate too much on the stability behavior of the SBWR, but he did state that the SBWR design was sufficiently different in several respects that its stability characteristics could be somewhat different from Dodewaard's. Factors affecting these differences include: small fuel pin diameter; longer core length; closer pin-to-pin spacing; overall core size (small cores are tightly coupled, larger cores are less so); chimney length; and, as noted previously, use of steam separation hardware in the SBWR versus free surface separation in Dodewaard.

A report including data from this test is scheduled for publication in approximately two months. In addition, while Dodewaard does not include data assessment in those reports, I was told that an internal report evaluating some of these tests has been published. While it exists in Dutch only at this time, Mr. Vayssier agreed to see if it could be translated and provided to the NRC. Furthermore, Mr. Vayssier will transmit to the NRC all data reports related to the Dodewaard tests that have been published to date.

Dr. van der Hagen, GKN, and KEMA have published several papers related to the stability testing and the Dodewaard stability monitoring system in international thermal-hydraulics conferences (e.g., NURETH-7, in Saratoga Springs, September 1995) and technical journals (e.g., *Nuclear Technology*). As previously noted, none of the testing is considered by GKN to be proprietary, and there appears to be a continued commitment to publishing pertinent open-literature papers.

I also raised a question regarding operation of the stability meter based on information we received during the 1993 visit. During that meeting, I had noted that, during startup, Dodewaard does not bring the stability meter on-line until the reactor reaches about 70% power, and that the reason for this was that the meter was not accurate below those powers. I learned in this meeting that that was not correct; in fact, the stability meter is accurate at any power level and was used during the low power testing to estimate the system decay ratio. The limiting criterion for accuracy of the meter is that the system is essentially <u>stationary</u>; i.e., no control rod movement and no rapid changes in neutron flux shape. During startup, at low powers, control rod withdrawal creates changes in the neutron flux profile, which would be read as indicators of instability by the meter. By the time the power reaches 70% the control rods are in position such that they will not interfere with the stability meter. If the system is at low power, <u>and</u> it is being maintained in an approximately stationary state, the stability meter can be used with acceptable accuracy.

One other issue aside from Dodewaard stability arose in our discussions. During lunch, Mr. Vayssier engaged me in a conversation about the U.S. approach to dealing with accidents beyond design basis, in part because I had mentioned the issue of regulatory treatment of non-safety systems (RTNSS) in the context of the passive plant design certification reviews. This is a topic of current discussion between the Dutch nuclear utilities and the KFD. To ensure availability of non-safety systems to respond to potential BDBAs, the regulatory authority is considering the imposition of some type of technical specifications or similar requirements on those systems. The Dutch utilities are resisting this approach, and negotiations are apparently ongoing between the parties. I explained that, for operating plants, our accident management approach was not to require technical specifications for non-safety systems, but that, in the NRC's view, existing regulations, such as the maintenance rule, plus other initiatives undertaken as part of the Accident Management program, provided sufficient assurance that non-safety systems would be available to respond to BDBAs. Mr. Vayssier requested that I send him some information on the U.S. Accident Management program, and I told him that I would follow up on his request when I returned to the U.S.

Overall, I found the visit to Dodewaard to be extremely valuable. The NRC will be receiving the data reports from the stability testing at Dodewaard, and will have direct access to a substantial database on natural circulation BWR stability. The discussions that we had were frank, open, and informative, and Dodewaard and TUD seem genuinely committed to performing these tests and getting the information into the public domain. While the KFD is somewhat concerned about testing that takes the plant into conditions requiring shutdown (such as the unstable oscillations resulting in scram), and may require adjustment of safety system setpoints for future tests, Mr. Vayssier was also clearly supportive of publication of this information.

<u>Other Observations and Concluding Remarks</u>

I believe that all of the objectives of this trip were accomplished: we completed the QA inspection of the PANDA program and discussed the technical aspects of the program with GE and PSI; we learned about Ansaldo's QA program and its interface activities with the U.S. vendors on the passive reactor testing programs; and I received a detailed explanation on the extensive stability-related testing at Dodewaard, the only facility of its kind in the world.

In light of GE's recent decision on the SBWR, it is unclear what the future of test facilities like PANDA and PANTHERS will be. Although they are not GE facilities, and were in fact funded and operated largely by GE's international associates, it remains to be seen how they will be utilized without SBWR

ATTACHM_NT 1

PRESENTATION MATERIALS AND OTHER DOCUMENTS

PROVIDED TO NRC STAFF

Fourth Int. Conference on Nuclear E gineering (ICONE-IV), New Orleans, Louisiana, USA

THE FIRST PANDA TESTS

by

J. Dreier, M. Huggenberger, C. Aubert, Th. Bandurski, O. Fischer, J. Healzer, S. Lomperski, H.-J. Strassberger, G. Varadi, and G. Yadigaroglu *

Thermal-Hydraulics Laboratory
Paul Scherrer Institute, PSI
CH-5232 Villigen PSI
Switzerland

ABSTRACT

The PANDA test facility at PSI in Switzerland is used to study the long-term Simplified Boiling Water Reactor (SBWR) Passive Containment Cooling System (PCCS) performance. The PANDA tests demonstrate performance on a larger scale than previous tests and examine the effects of any non-uniform spatial distributions of steam and non-condensables in the system. The PANDA facility has a 1:1 vertical scale, and 1:25 "system" scale (volume, power, etc.). Steady-state PCCS condenser performance tests and extensive facility characterization tests have been completed. Transient system behavior tests were conducted late in 1995; results from the first three transient tests (M3 series) are reviewed. The first PANDA tests showed that the overall global behavior of the SBWR containment was globally repeatable and very favorable; the system exhibited great "robustness."

1 INTRODUCTION: THE SBWR AND PANDA

This paper describes the first experiments conducted at the large-scale PANDA test facility, within the framework of the ALPHA project conducted at the Paul Scherrer Institute (PSI) in Switzerland (Coddington et al., 1992). The goal of the ALPHA project is the experimental and analytical investigation of the long-term decay heat removal from the containment of the next generation of "passive" ALWRs; the effects of aerosols on containment performance are also considered. The ALPHA project and the PANDA experiments have been, so far, mainly directed to the investigation of the General Electric (GE) Simplified Boiling Water Reactor (SBWR) Passive Containment Cooling System (PCCS).

The SBWR uses gravity or natural circulation-driven, passive safety systems to provide emergency core coolant in case of a break in the primary system, to keep the core cooled and to remove decay heat from both the primary system and/or the containment (Upton et al., 1993). The main systems performing these tasks are the Gravity-Driven Cooling System (GDCS), the Isolation Condenser System (ICS), and the Passive Containment Cooling System (PCCS), Fig. 1.

Emergency core cooling water is provided to the core by the GDCS. This system consists of three water pools situated above the top of the core, from which makeup coolant can flow by gravity to replenish the coolant lost from the Reactor Pressure Vessel (RPV). However, the GDCS can operate only after depressurization of the RPV; therefore, the SBWR is equipped with an Automatic Depressurization System (ADS) that performs this function. The depressurization of BWR primary systems is well understood, since it has been studied extensively in relation to the classical BWR designs.

Decay heat removal from the primary system while it is intact or under high pressure is performed by the ICS. The ICS consists of three Isolation Condensers (IC) located in a pool on top of the reactor building. When redundant condensate return valves are opened, the water contained in the IC condenser tubes drains and steam from the primary system flows into the tubes, condenses, and returns to the RPV, removing stored energy. The behavior of the ICS is also well understood, since such units have been in operation for many years in older BWRs.

Decay heat is removed from the drywell (DW) by the PCCS, which employs three PCC condensers, also located in interconnected PCCS pool compartments on top of the reactor building. The PCC condenser tubes are permanently connected to the DW. A mixture of steam and noncondensable gases (nitrogen present in the containment during normal operation) may enter the PCC condensers. The steam will condense, while the noncondensable gases must be vented to assure proper operation of the condensers. This is accomplished by conveying and venting the noncondensable gases into the suppression pool (SP) in the Suppression Chamber (SC) (or Wetwell). Since the DW volume is connected directly to the SP either via the main pressure suppression vents or through the PCC condensers and their vent lines, the path that the steam will follow depends on the pressure

*main affiliation: Swiss Federal Inst. of Technology (ETH), ETH-Zentrum / CLT, CH-8092 Zurich

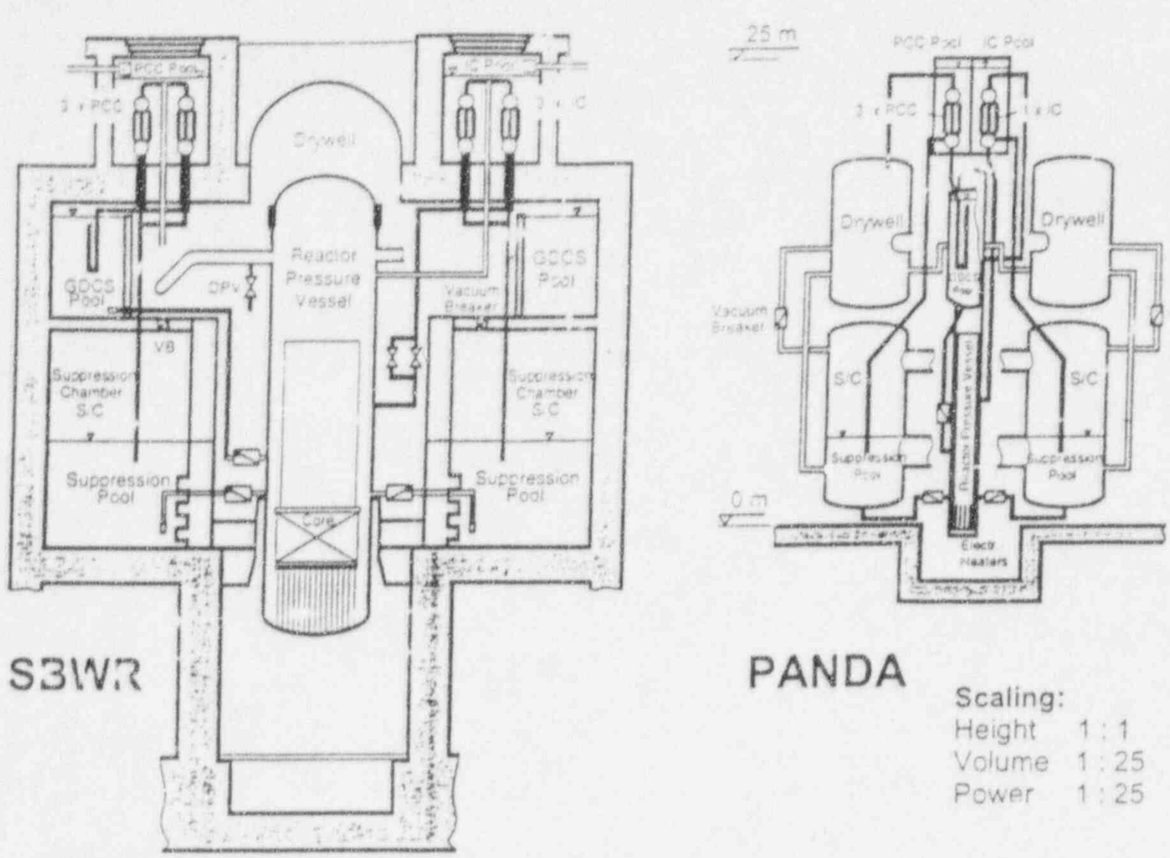


Fig. 1 Schematic illustration of the SBWR and of the PANDA facility (at the same scale)

differences between the DW volume and the two possible venting points. During the long-term containment cooling period, direct opening of the main vents and condensation of the steam in the SP must be avoided, since the SP is not provided with a safety-grade cooling system; the steam must be condensed in the PCC (or IC) condensers and any noncondensables vented to the SC. Although the operation of the condensers is understood, experimental verification of their integral, system behavior under a variety of conditions was deemed necessary. There are vacuum breakers installed between the DW and the SC in the SBWR; their function is to open and to equalize the pressures in these two containment compartments when the DW pressure falls below the SC pressure. The effects of their operation are also further investigated.

Two experimental facilities are being used for verifying integral SBWR containment performance. The GIRAFFE facility, operated by Toshiba in Japan (Yokobori et al., 1991), provided extensive information about system behavior. The larger-scale PANDA facility, is providing additional information by addressing issues such as the effects of the operation of several condenser units in parallel, the distribution of the constituents (steam and noncondensables) in the large DW volume, and mixing in the containment compartments.

The accident scenarios investigated in PANDA relate to the *long-term cooling phase* of the SBWR, beginning when the RPV inventory starts becoming replenished by the condensate flowing down from the ICS and PCCS. At about the same time, the ICS and PCCS condensers become the dominant decay heat removal mechanism, replacing the heat sink provided by the water inventory initially stored in the GDCS pools.

PANDA is a large-scale integral-test facility, specifically designed and constructed for the needs of the ALPHA project. It is presently configured to represent at a 1:25 scale the containment of the SBWR. The tests described here were initially expected to bring only confirmatory information for the certification of the SBWR by the United States Nuclear Regulatory Commission (US NRC). Recent developments have made the first series of experiments to be conducted in PANDA a *required* experimental element in the certification process; thus, the tests are now performed according to the NQA-1 Quality Assurance procedure.

The SBWR confirmatory research and later the certification effort are conducted in collaboration with a large international team. The closest PSI partners in this team have been the Electric Power Research Institute (EPRI), the General Electric Company (GE) and the University of California-Berkeley (UCB) in the US, the Netl lands Energy Research Foundation (ECN) and KEMA in the Netherlands, the Toshiba Corporation in Japan, the Instituto de Investigaciones Eléctricas (IIE) in Mexico, and the Italian national utility ENEL, as well as ENEA, Ansaldo, and SIET in Italy. Elements of the SBWR international program closely linked to the ALPHA project are:

- Single-tube condensation experiments at UCB (Vierow & Schrock, 1991; Kuhn et al., 1995) and at MIT (Siddique et al., 1993).
- The smaller scale (1:400) integral test facility GIRAFFE operated by Toshiba (Yokobori et al., 1991).
- The full-scale PCCS condenser qualification PANTHERS experiments performed by SIET in Italy (Botti et al., 1994).

Tests in the PANDA facility started at the beginning of 1995 (Varadi et al., 1995). The first tests were steady-state PCCS condenser performance tests, as counterpart tests to those conducted at the PANTHERS and GIRAFFE facilities. Extensive facility characterization tests were completed in July 1995: the facility leak rates, heat losses, as well as the pressure-drop–flow-rate characteristics of the various lines were obtained. These are needed for the accurate ...ription of the facility in computations. The first three transient system behavior tests were conducted in October 1995 and the remaining series of transient tests intended for SBWR certification were completed at the end of 1995.

In addition to the large-scale PANDA tests, small-scale experiments and numerous analyses were conducted at PSI to better understand basic phenomena and SBWR system behavior, to provide preliminary data for the development of computational models, etc.

2 THE PANDA LARGE-SCALE FACILITY

The PANDA general experimental philosophy, facility design, scaling, and measurement concepts are described by Coddington et al. (1992). During the early project definition period, it was decided to build a large-scale facility capable of simulating SBWR behavior during the long-term (or PCCS-cooling) phase of the postulated Loss-of-Coolant Accident (LOCA). The tests cover the LOCA phase that starts typically one hour after scram. They are intended to investigate mainly any three-dimensional effects that may be present during this phase. Thus, in relation to the SBWR certification effort, the PANDA transient test objectives are to demonstrate that:

- Containment performance is similar in a larger-scale, multidimensional system to that previously demonstrated with the smaller-scale GIRAFFE tests.
- Any non-uniform distributions in the containment do ...t create significant adverse effects.
- There are no adverse effects associated with multi-unit PCCS operation and interactions with other reactor systems.

The tests also extend the data base available for code qualification in general and, in particular, serve to further validate the system code TRACG (Andersen et al., 1993).

2.1 Conceptual Design

It is neither possible nor desirable to preserve exact geometrical similarity between the SBWR containment volumes and the experimental facility (Coddington et al., 1992), in spite of the fact that multidimensional containment phenomena such as mixing of gases (steam and noncondensables) and natural circulation between compartments may depend on the particular geometry of the containment building. Any attempt to reproduce the complex geometry of the SBWR in the PANDA facility would have been futile; the various phenomena taking place in the containment are complex and simple linear geometric scaling would have rather produced serious scaling distortions.

The various containment volumes were instead represented by interconnected simple cylindrical vessels. The general philosophy followed in designing the experimental facility was to allow any multidimensional effects to take place by dividing the main containment compartments (Drywell and Suppression Chamber) in two to allow for spatial distribution effects to manifest themselves. A variety of well-controlled boundary conditions (e.g., imbalances) can be imposed during the experiments, to study the various phenomena under well-established conditions, and in certain cases establish an envelope for the behavior of the system. Carefully conducted "parametric" or sensitivity experiments can also provide more valuable data for code qualification, than attempts to simulate geometrically, but to a necessarily limited degree, the rather complex reactor system. Boundary conditions and the interconnections between containment ...umes and their behavior can be controlled to study various system scenarios and alternative accident paths.

Following this general philosophy, the SBWR Reactor Pressure Vessel (RPV) and the Gravity-Driven Cooling System (GDCS) pools are represented each by one vessel. The Drywell (DW) and Suppression Chamber (SC or Wetwell) are represented both by two separate, interconnected vessels (Figs. 1 and 2). The RPV contains a 1.5 MW electrical heat source. The electric "core" geometry and the heater rod dimensions are not intended to match those of the SBWR reactor core; they merely provide the necessary amount of heat to the RPV. The RPV internals (chimney height, etc.) also resemble those of the SBWR. The parameters of importance for global system behavior, namely, the RPV water inventory and water level are accurately scaled.

There is a total of three PCCS condensers representing the corresponding three units in the SBWR and a single ICS condenser representing two of the three corresponding SBWR units. (The two SBWR ICS condenser units correspond to the 2x50 % design value of the cooling capacity; the third ICS condenser is an extra 50 % redundant unit.) The condensers are connected to the two DW vessels, as shown in Fig. 2. The fact that there are three PCC units and only two DW volumes allows some degree of asymmetric behavior or creates flows between the two DWs, even with equal flow areas from the RPV to the two DW volumes.

There are two vacuum breakers connecting the two DWs to the two SCs in PANDA. The operation of the actual vacuum breakers of the SBWR is simulated in PANDA by the controlled opening of valves; these are opened and closed by the facility control system when the measured differential pressure signal between the DWs and SCs exceeds an upper and a lower limit, respectively). Figure 2 shows some of the details of the piping interconnecting the various volumes.

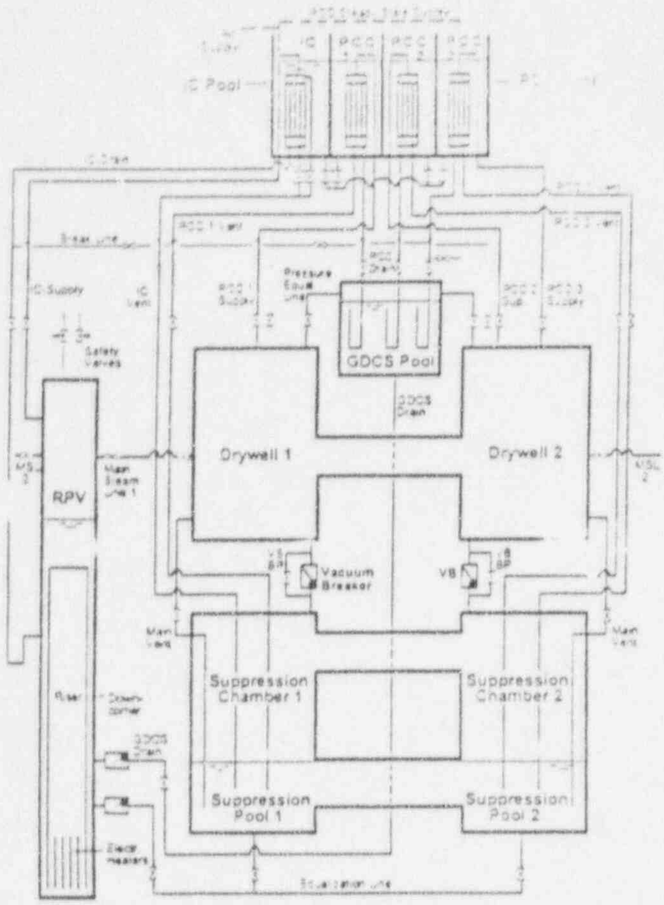


Fig. 2 Piping connections and process lines of the PANDA facility

2.2 Scaling of the PANDA Facility

In relation to scaling, both "top-down" and "bottom-up" (Zuber, 1991) scaling considerations and criteria were developed. General, "top-down," scaling criteria are derived by considering the processes controlling the state of classes of containment sub-systems (e.g., containment volumes, pipes, etc.) (Yadigaroglu, 1996). Close examination of specific phenomena or system components (e.g., thermal plumes, vents, etc.) leads to "bottom-up" scaling rules.

Rigorous scaling studies (Yadigaroglu, 1994; Gamble et al., 1995) describe the scaling rationale and scaling details of the PANDA facility. Additional work (Coddington and Andreani, 1995; Andreani and Tokuhiro, 1995) covers certain particular aspects of scaling.

Prototypical fluids under prototypical thermodynamic conditions are used in PANDA; the nitrogen filling initially the containment is, however, replaced by air - the difference is of no importance. The fact that the fluids are expected to be in similar thermodynamic states and have similar composition in the prototype and the model simplifies the scaling of the facility.

The top-down scaling study confirmed the validity of the (familiar) scaling of all the following variables with the "system scale," R:

$$(\text{power})_R = (\text{volume})_R = (\text{horizontal area in volume})_R$$
$$= (\text{mass flow rate})_R = (\text{heat transfer areas})_R = R$$

where the subscript R denotes the ratio between the corresponding scales of prototype and model. For PANDA, R = 25. The PANDA core power can be programmed to automatically follow a decay heat curve.

In the BWRs, and particularly during the PCCS-cooling phase of the LOCA considered here, the important pressure drops and the corresponding junction flows are controlled by the submergence depth of vents in the Pressure Suppression Pool or by hydrostatic pressure differences between interconnected liquid volumes (e.g., the RPV and GDCS pool liquid spaces). The analyses of these processes justify the choice of

1:1 scaling for pressure differences, elevations, levels, submergence depths and time.

This scaling rule determines the pipe diameters, lengths, and hydraulic resistances, and indirectly dictates the transit times between volumes. These transit times should, in principle, have the same (1:1) time scale as the time constants controlling the filling or pressurization rates of system volumes. This matching cannot be perfect but the distortion is shown to be negligible, since the transit times are much shorter than the volume filling or pressurization times.

For the types of transients taking place in the SBWR, the average pressure drops between containment volumes are not expected to be dominated by inertial effects (very rapid changes in flow rates). Thus, the inertial characteristics of the piping (i.e., the lengths of piping and the velocities in these pipes), do not have to be scaled exactly. Usually (and fortunately), the total pressure drops in the piping are dominated by local losses, so that the total pressure drops in the scaled facilities and in the prototype can be matched by introducing adequate local orifice losses.

Close examination of the *specific* phenomena governing the operation of certain system components (e.g., vents immersed in the Pressure Suppression Pool of the SBWR) led to "bottom-up" scaling rules. Bottom-up scaling (Yadigaroglu, 1994; Gamble et al., 1995) was applied for phenomena and facility components that were selected as being of particular importance by a Phenomena Identification and Ranking Table (PIRT) exercise. These include the scaling of thermal plumes, mixing and stratification phenomena in the Pressure Suppression Pool, as well as in the Drywell volume, of heat and mass transfers at liquid-gas interfaces, of the heat capacity of containment structures, etc. Of particular importance is also the scaling of the various vents discharging mixtures of steam and noncondensable gases into the Pressure Suppression Pool. The importance of heat losses was considered in detail and the facility was very heavily insulated to minimize losses. The facility heat losses have been carefully measured, as discussed in Section 4.

Condensation in the presence of noncondensables inside the PCCS and ICS condensers tubes is perfectly scaled since the PANDA condenser tubes have prototypical dimensions and are expected to work under prototypical conditions. Heat transfer on the secondary pool side may be affected by natural circulation in the pool. Although the PANDA PCCS and ICS pools have smaller scaled surface areas than the SBWR pools, water can be added during the experiments in a controlled manner to compensate for the smaller water inventory. Other strategies for conducting the experiments are also possible. For example, during certain tests the system reaches virtually a steady state and changes are only driven by the decay of the core power. Under such conditions, the tests can be "accelerated" by accelerating the reduction of core power.

3 INSTRUMENTATION AND DATA ACQUISITION

The facility is heavily instrumented with some 600 sensors for temperature, pressure, pressure difference, level or void fraction, flow rate, gas (oxygen or air) concentration, electrical power, valve position, and presence-of-phase measurements.

A very large number of thermocouples measure not only fluid temperatures, but also vessel and pipe wall temperatures; these are used to obtain accurate heat balances and to estimate the heat losses from the various facility components.

The data acquisition system can sample and store all instrumentation channel readings continuously with a frequency of 0.5 Hz and for short periods of time with a "burst" frequency of 5 Hz. The facility is operated and controlled remotely and interactively by a computer-screen-based system.

4 PRELIMINARY SERIES OF TESTS

The very first series of PANDA experiments conducted at the beginning of 1995 were *steady-state PCCS condenser performance tests*, as counterpart tests to certain tests conducted at the PANTHERS and GIRAFFE facilities (Varadi et al., 1995). In this first series of tests, the effect of noncondensables on condenser performance was investigated. Thus, the tests were conducted mostly at constant steam flow rate and variable noncondensable mass fraction.

Figure 3 shows the condenser efficiency, defined as the fraction of inlet steam condensed, as a function of the noncondensable mass fraction, at the reference steam flow rate. As expected, the condenser efficiency diminishes as the noncondensable mass fraction increases. The figure contains also blind pre-test predictions obtained with the TRACG code. The code used the Vierow and Schrock (1992) correlation for condensation inside the tubes and the Chen (1963) correlation for heat transfer from the tube wall to the pool. The trends predicted by TRACG are in excellent agreement with the experimental ones. The TRACG values are quantitatively slightly conservative (i.e., they tend to underpredict condenser performance).

Extensive *facility characterization tests* were completed in July 1995: the facility leak rates, heat losses, as well as the pressure-drop–flow-rate characteristics of the various lines were obtained (Varadi et al., 1995). These are needed for the accurate description of the facility in computations. The measured total facility losses met and exceeded the heat loss criteria initially established to design the facility: they did not exceed about 7 % of the expected scaled reactor decay heat power at 24 hrs after scram (the design target was 10 %). In

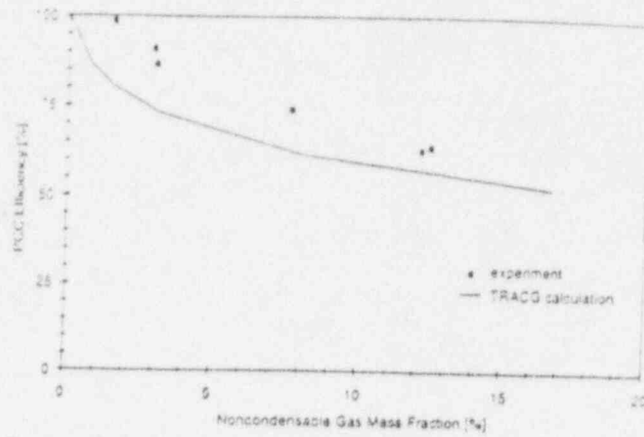


Fig. 3 Steady-state condenser characterization tests: measured condenser efficiency, as function of noncondensable mass fraction, compared to TRACG pretest predictions.

reality, the actual losses during a typical test will be even lower, since the SCs will be at a lower temperature.

The remaining facility characterization tests (Varadi et al., 1995) demonstrated that the pressure-drop flow-rate characteristics of the lines matched the ones of the SBWR system.

5 PRECONDITIONING: ESTABLISHMENT OF THE PROPER INITIAL CONDITIONS FOR THE TESTS

The PANDA facility is equipped with auxiliary air and water supply systems for preconditioning the contents of the various system components (Varadi et al., 1995). In particular, the facility is equipped with an *auxiliary water system* connectable to top and bottom filling ports in all vessels and pools. The system includes cooling and heating capability; for heating, heat is drawn from the RPV via an auxiliary water system heat exchanger.

For the M3 series of tests described here, the following typical preconditioning procedures were followed. Before test initiation, the various containment volumes were isolated, filled with demineralized water, steam from the RPV or air, and further heated, as necessary, using heat from the RPV via the preconditioning-system heat exchanger. Air was eliminated, by purging with steam, when necessary.

More specifically, the RPV was first heated to about 170 °C (corresponding to a saturation pressure of about 7.5 bar) with a sufficiently high water inventory, in anticipation of the heating needs for the entire facility. The two SCs were then filled with water at the desired (uniform) initial temperature. The preconditioning was conducted in a way assuring a uniform SC air space temperature; steam was injected to heat up the air space. The partial pressure of the steam in the gas spaces of the two SCs was set by the water temperature. Finally, the required amount of air was injected to adjust the partial pressure of the air at its specified initial value. The GDCS vessel was initially empty for the tests discussed here but at a uniform (air space and wall) temperature. This was achieved by steam heating of the structures, and by initially filling the vessel with hot water and then transferring this water to the PCCS pools. The PCCS (and whenever used, also the ICS) pools were simply filled with hot water to the desired level(s).

For the M3 series of tests, no water and very little air was required in the two DWs. An accurate adjustment of the initial air partial pressure in the DWs was achieved as follows: the vessels were first heated and purged of practically all air by steam injection. However, *some* air accumulated during this time in the PCC condensers that condensed *some* steam, since they had their secondary side at the lower (PCC pool) temperature. This air was of course still present in the condenser tubes at test initiation. The pressure in the DWs was then recorded and a sufficient amount of air was injected to increase the vessel pressure by the amount of the required initial partial pressure of air. This partial air pressure adjustment and measurement relies upon the measurement of a pressure *difference* and is therefore quite accurate.

Just before test initiation all initial conditions were verified and further fine-adjusted, if necessary. When the required initial conditions were reached, vessel connections were opened to bring the system into the required configuration. Certain instruments that had to be isolated during the preconditioning phase were lined up and instrument zero checks were conducted (e.g., by physically equalizing the pressures on the two sides of differential pressure transducers). The status of all system valves was verified and recorded. Finally tests were started by opening the Main Steam Line (MSL) valves and starting the power transient. Clearly, the last steps of the startup procedure must be carried out very rapidly (a few minutes). The length of the preconditioning phase depends on the state of the facility at the beginning of the test, and is of the order of a day or two.

Experience from the first tests has shown that the specified initial conditions could be matched very precisely (e.g., for temperatures within less than ± 2 K, for pressures within ± 4 kPa, and for levels within ± 0.1 m or less). The uniformity of temperature within the various pressure vessels was also excellent (as measured, within less than 1 K). The specified core power decay curve could be perfectly and smoothly followed thanks to the actions of the automatic control system that was programmed to sequentially activate and control the power (in small steps) of the electric heaters simulating the core.

For the M3 series of tests discussed here, the three PCC condensers were connected to the two DWs (PCC-1 to DW-1 and PCC-2 and PCC-3 to DW-2), as shown in Fig. 2. The IC condenser was valved off. The corresponding IC pool was empty for tests M3, and full of hot water for tests M3A and M3B. The difference between the three M3 series of tests discussed here is in the way the PCCS and ICS pools were connected and their water levels maintained, as discussed below.

6 THE M3 SERIES TRANSIENT SYSTEM BEHAVIOR TESTS

A test matrix for a series of containment and systems interaction tests for SBWR certification has been established. The test matrix is set in such a way that the first tests are parametric variations around a base test, that is a counterpart test to one of the GIRAFFE tests. Thus, any effects of system scale and of non-uniformities in the system will become apparent.

The first tests discussed here (tests M3, M3A and M3B, referred to as the M3 Series) are MSL Break (MSLB) tests. The initial conditions for these tests are the state of the system one hour after scram during the LOCA: at that time the DW contains mostly steam and almost all the air has been pushed into the SC. The tests are similar to a GIRAFFE MSLB test with uniform DW conditions.

The M3 series of tests investigated the effect of the water level and inventory in the PCC pools on system performance. The PANDA pools have a scaled cross-sectional area about three times smaller than the SBWR pool area. Water can be added during the tests to provide the missing water inventory. The pool conditions can, however, be modified by such water makeups to the pools. To investigate these effects, the M3 series of tests were conducted as follows:

- For test M3 the three PCC pools were interconnected and there was no water makeup. At the end of test M3, the water level in the PCC pools had dropped about 0.5 m below the top of the tubes.
- Test M3A was conducted with the three PCC pools isolated; cold water was added from the bottom fill line (Fig. 2) to each

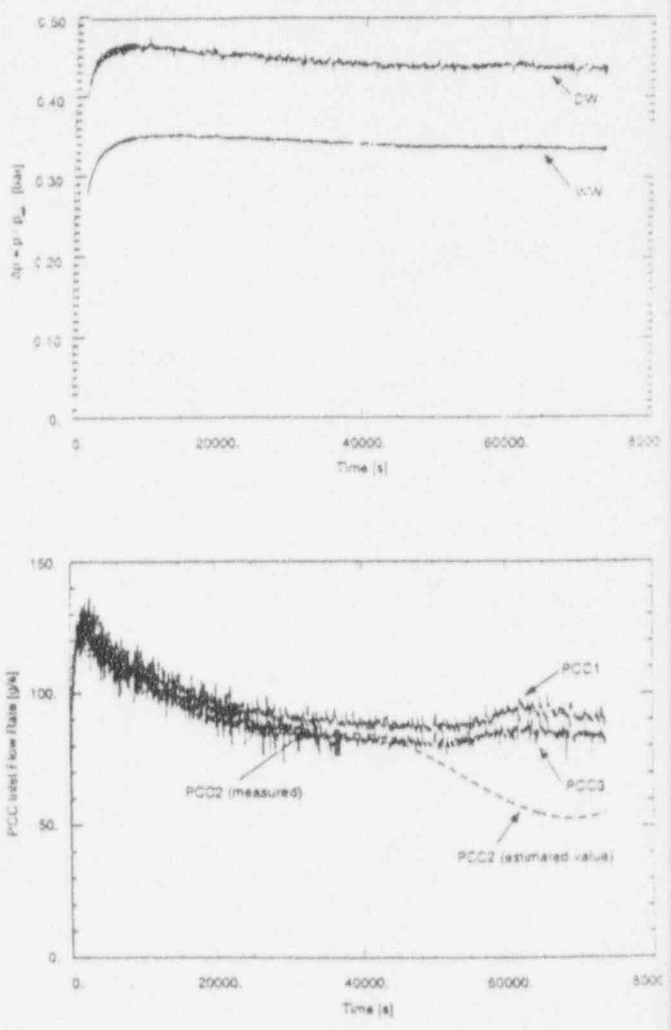


Fig. 4 Test M3: Variation of the DW and WW pressures (top) and of the flow rates received by the three PCC condensers (bottom).

pool individually, to keep its nominal water level constant within ± 0.3 m.

- For test M3B, the three pools were interconnected and water was added simultaneously to all three (using the connecting bottom-fill line) to keep again the nominal water level within ± 0.2 m.

All three tests were conducted with identical initial and power decay conditions and with initially saturated water in the PCC pools.

The gradual drop by evaporation of the water level in the pools provides a very good measure of the integral power evacuated by the PCC condensers. For test M3A (isolated pools), individual heat balances on the three PCC units could be performed. These confirmed certain findings regarding the non-uniform operation of the three PCC units.

The DW and WW pressures followed very similar global trends in the three tests. The peak DW pressures reached were very close to one another. After an initial pressure increase period that lasted about two hours, the DW pressure stabilized and varied very little thereafter, as shown in Figs. 4, 5 and 6 for tests M3, M3A, and M3B, respectively. The pressure increase period corresponded roughly to the time needed to practically purge all steam from the DW. Thereafter, the difference between the DW and WW pressures remained practically constant (except around vacuum breaker openings); the difference represented the submergence depth of the PCC vent in the WW pool.

Test M3 showed quite uniform behavior of the three PCC units up to about 35 000 s, as shown in Fig. 4. Then, PCC-2 started absorbing progressively less steam, while slightly *more* steam was condensed by the other two units (PCC-1 and PCC-3). The reduced performance of PCC-2 could be verified by a number of indicators (subcooling of the lower part of the PCC-2 pool, strong reduction of boiling in the PCC-2 pool, variation of the axial temperature profiles in the PCC-2 condenser tubes with a movement of the "full condensation boundary" upwards, etc.) and is apparently connected to a filling up of the PCC-2 condenser tubes with noncondensables up to a certain level. No vacuum breaker opening took place in test M3, and the three PCC units essentially shared the load and condensed the exact amount of steam provided by the RPV. Figure 4 shows the variation of the DW pressure and of the PCC feed flows during this test.

As noted, the lesser water inventory in the PANDA pools and the absence of water makeup resulted in a non-prototypical, low water level in the pools; for this reason, tests M3A and M3B were performed. In these two tests the water level in the pools was kept constant, as already noted. The pools were isolated and filled individually with cold water during test M3A, as shown in Fig. 5. The cold water was introduced from the bottom of the pools and apparently remained at the bottom until its level reached the bottom of the condenser tubes. This resulted then in mixing of the pool water and in a reduction of the pool temperature, a consequent increase in the heat transfer rate and eventually an increase of the condensation rate that has driven the DW pressure below that of the WW and produced vacuum breaker openings. After vacuum breaker openings the pressure in the WW dropped slightly also and the oxygen probes installed in the DW recorded the expected increase in air content. The effect of vacuum breaker openings did not last long, however, and the DW and WW pressures increased to their pre-vacuum-breaker-opening levels in less then an hour.

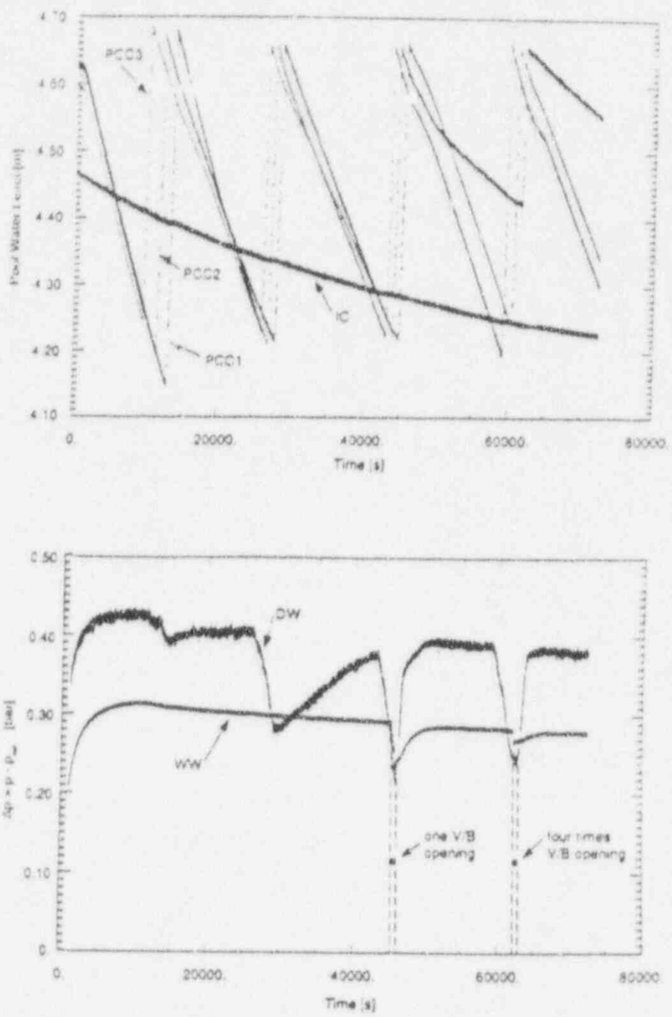


Fig. 5 Test M3A: Recorded PCCS Pool levels showing the procedure followed for maintaining an approximately constant level (top) and DW and WW pressures showing two clusters of vacuum breaker openings (bottom).

With or without vacuum breaker openings, the DW pressure decreased slightly after refilling of the pools in tests M3A and M3B, as shown in Figs. 5 and 6; the effect was strongest for later refills, when the cold water that was injected at the bottom of the pool could rise sufficiently and mix with the upper layers of the pool.

Vacuum breaker openings were more frequent during test M3A, where apparently the individual filling of the pools had a stronger effect, as shown in Fig. 5. Only a single cluster of two vacuum breaker openings took place late during test M3B, where apparently the "milder" changes in the pool temperatures produced a lesser effect. This is shown in Fig. 6.

The air content of the DWs increased momentarily following the vacuum breaker openings, the condensation rates of the individual PCC units were affected, but because of the very large margin built into the system, the three PCC units always managed to share the load and the long-term behavior of the DW pressures was not affected.

Following a drop in DW pressure due to filling up of a pool, when the DW was full with almost pure steam, the DW pressure recovery was slow, since high rates of condensation in the PCC units kept the DW pressure low (as shown following the first DW pressure drops in Figs.5 and 6) and a long time was needed to partly fill up again the PCC tubes with air. On the contrary, when there was more air in the DW, the recovery of the DW pressure was relatively rapid (as shown for the later DW pressure drop transients in Figs. 5 and 6). In this case air present in the DW could accumulate rather rapidly in the PCC tubes and reduce their heat removal capability.

7 CONCLUSIONS

The first transient M3 Series of tests were conducted successfully in October 1995. Regarding facility design and operation, these tests demonstrated the following:

- The facility can be operated and controlled very well, and very narrowly defined initial test conditions and boundary conditions (initial states of various containment volumes, power input, etc.) can be achieved.
- The pre-conditioning equipment worked very successfully in this respect.
- The instrumentation performed with high accuracy and reliability.

Preliminary and necessarily limited and tentative findings concerning the cooling system are: SBWR long-term containment

- The overall global behavior of the containment was very favorable; the system exhibited great "robustness." The PCCS units were able to perform their function under all conditions tested so far.
- The tests showed very good repeatability of overall system behavior (DW and SC pressures) in spite of differences in the sharing of the condensation load among the three PCC condensers and differences in vacuum breaker openings.

There are interesting findings regarding the distribution of noncondensables and their effects on the PCCS system. Small amounts of noncondensables seem to affect the status of the condensers operating in parallel. The *global* operation of the PCCS system does not, however, seem to be influenced by such possible dissymetries and three-dimensional effects, as noted above. This is reassuring since, indeed, PANDA was built to investigate such effects.

The data from the M3 test series are still being analyzed in detail and compared to pre- and post-test calculations. Definite conclusions will be obtained after examination and analysis of all the data.

ACKNOWLEDGMENTS

The ALPHA project, conducted at PSI in cooperation with the Electric Power Research Institute (EPRI) and the General Electric Company (GE), receives financial support from the Nuclear Power Committee of the Swiss Utilities (UAK), the (former) Swiss National Energy Research Foundation (NEFF) and GE; these financial contributions are gratefully acknowledged.

This paper results from the collaboration of a large number of persons both inside PSI as well as outside. The authors particularly acknowledge the contributions of PSI collaborators P. Coddington and B. Uebelhart during the early phases of the project, of L. Voser for design, construction and resolution of many instrumentation problems, and of P. Gritsch, W. Bulgheroni and P. Rasmussen for facility controls and data acquisition systems. The authors are also indebted to J. Yedidia of EPRI who was instrumental in organizing the ALPHA program and to their numerous GE colleagues who con-

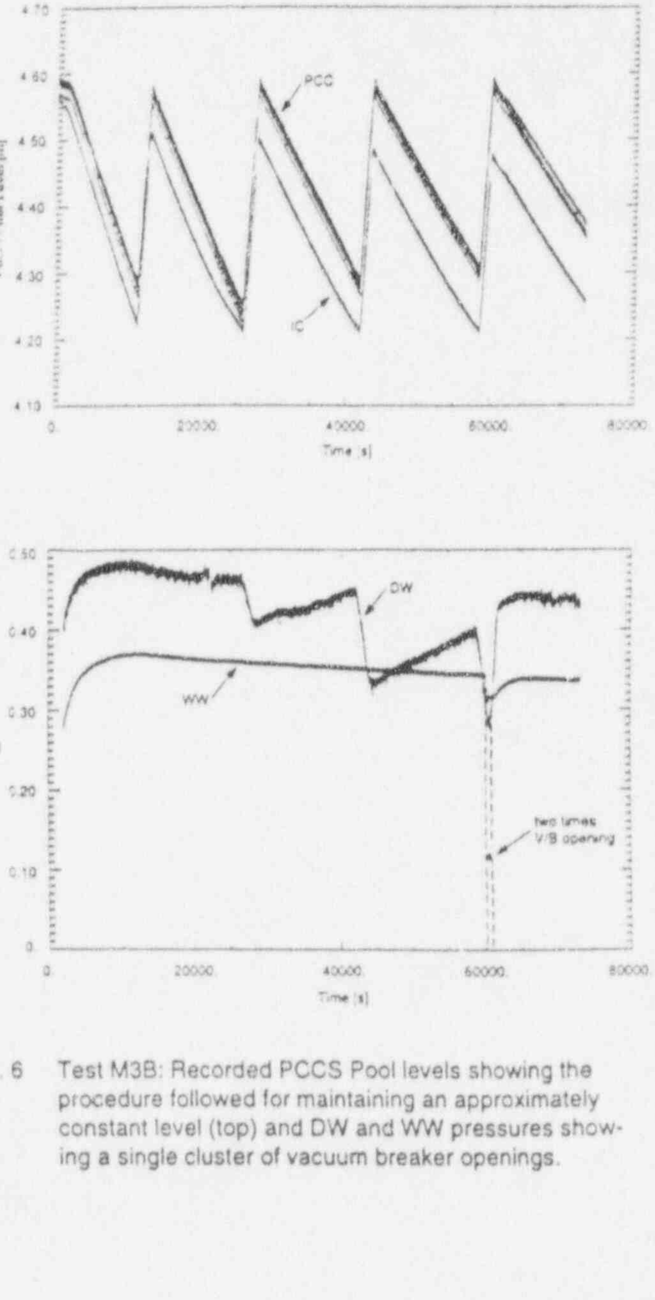


Fig. 6 Test M3B: Recorded PCCS Pool levels showing the procedure followed for maintaining an approximately constant level (top) and DW and WW pressures showing a single cluster of vacuum breaker openings.

tributed time and effort, in particular to A. Rao, J. Fitch, B. Shiralkar J. Torbeck, A. Arretz, B. Usry and B. Wingate.

REFERENCES

Andersen, J.G.M. et al., 1993, "TRACG Qualification," Licensing Topical Report, NEDE-32177P, Class 3 (February 1993).

Andreani, M. and Tokuhiro, A., 1995, "Condensation in the Spout Region of a Gas-Vapor Plume Rising in a Subcooled Water Pool," pp. PC2-17 24 in *Proceedings, The 2nd Int. Conference on Multiphase Flow '95, Kyoto*, April 3-7, 1995, Kyoto, Japan, Vol. 2.

Botti, S. et al., 1994, "Tests on Full Scale Prototypical Condensers for SBWR Application," European Two-Phase Flow Group Meeting, SIET, June 6-8, 1994.

Chen, J.C., 1963, "A Correlation for Boiling Heat Transfer to Saturated Fluids in Convective Flow," ASME paper 63-HT-34; also: *Ind. Engng. Chem., Process Des. Devel.*, 5, 322 (1966).

Coddington, P., Huggenberger, M., Guntay, S., Dreier, J., Fischer, O., Varadi, G., and Yadigaroglu, G., 1992, "ALPHA: The Long-Term Decay Heat Removal and Aerosol Retention Programme," pp. 203-211 in *5th International Topical Meeting on Nuclear Reactor Thermal Hydraulics (NURETH-5)*, Salt Lake City, USA, Sept. 1992.

Coddington, P. and Andreani, M., 1995, "SBWR PCCS Vent Phenomena and Suppression Pool Mixing," pp. 1249-127 , in *Proceedings of the 7th Int. Meeting on Nuclear Reactor Thermal-Hydraulics NURETH-7*, Saratoga Springs, New York, September 10-15, 1995, NUREG/CP-0142, Vol. 2.

Gamble, R.E., Hunsbedt, A., Moody, F.J., Parker, M.K., and Yadigaroglu, G., 1995, "Scaling of the SBWR Related Tests," GE Nuclear Energy report NEDC-32288P, Rev. 1, Class 3 (October 1995).

Huggenberger, M., 1991, "PANDA Experimental Facility Conceptual Design," PSI internal report AN-42-91-09, ALPHA-105.

Ishii, M. and Kataoka, I., 1983, "Similarity Analysis and Scaling Criteria for LWR's Under Single-Phase and Two-Phase Natural Circulation," NUREG/CR-3267 (ANL-83-32).

Kuhn, S.Z., Schrock, V.E. and Peterson, P.F., 1995, "An Investigation of Condensation from Steam-Gas Mixtures Flowing Downward Inside a Vertical Tube," pp. 312-335 in *Proceedings of the 7th Int. Meeting on Nuclear Reactor Thermal-Hydraulics NURETH-7* Saratoga Springs, New York, September 10-15, 1995, NUREG/CP-0142, Vol. 1.

Siddique, M., Golay, M.W., and Kazimi, M.S., 1993, "Local Heat Transfer Coefficients for Forced Convection Condensation of Steam in a Vertical Tube in the Presence of a Non-Condensable Gas," *Nucl. Technol.*, Vol. 102, p. 386.

Upton, H.A., Cooke, F.E., Sawabe, J.K. (1993), "Simplified Boiling Water Reactor Passive Safety Features," pp. 705-712, Vol. 1, in *Proc. 2nd ASME-JSME Nuclear Engineering Joint Conf.*, P.F. Peterson (ed.).

Varadi, G., Dreier, J., Bandurski, Th., Fischer, O., Huggenberger, M., Lomperski, S., and Yadigaroglu, G., 1995, "The PANDA Tests for SBWR Certification," *Twenty-Third Water Reactor Safety Research Information Meeting*, October 23-25, 1995, Bethesda, Maryland.

Vierow, K.M. and Schrock, V. E., 1992, "Condensation in a Natural Circulation Loop with Non-Condensable Gases, Part I Heat Transfer," *Proc. Int. Conf. Multiphase Flows*, Tsukuba, Japan, September 1991.

Yokobori, S., Nagasaka, H., Tobimatsu, T., 1991, "System Response Test of Isolation Condenser Applied as a Passive Containment Cooling System," *1st JSME/ASEM Joint International Conf. on Nuclear Engineering (ICONE-I)*, Nov. 1991, Tokyo.

Yadigaroglu, G., 1994, "Scaling of the SBWR Related Tests", GE Nuclear Energy report NEDC-32288 (July 1994).

Yadigaroglu, G., 1996, "Derivation of General Scaling Criteria for BWR Containment Tests" paper prepared for the 4th Int. Conf. on Nuclear Engineering, ICONE-4, New Orleans, Louisiana, March 10-14, 1996.

Zuber N., 1991, "Hierarchical, Two-Tiered Scaling Analysis," Appendix D to "An Integrated Structure and Scaling Methodology for Severe Accident Technical Issue Resolution," Nuclear Regulatory Commission Report NUREG/CR-5809, EGG-2659 (November 1991).

ANSALDO

Un'Azienda Finmeccanica

Divisione Nucleare

AGENDA

MEETING IN GENOA, ITALY
ANSALDO OFFICE
CORSO PERRONE, 25
GENOA, ITALY
VILLA CATTANEO

March 11, 1996

09.00 ANSALDO GROUP PRESENTATION

09.15 NUCLEAR DIVISION PRESENTATION

09.30 DISCUSSION OF OVERALL INTERFACES BETWEEN ANSALDO AND GE NUCLEAR ENERGY AND WESTINGHOUSE RELATED TO QUALITY ASSURANCE FOR DESIGN CERTIFICATION

10.30 COFFEE BREAK

10.45 DISCUSSION AND QUESTIONS

12.30 LUNCH

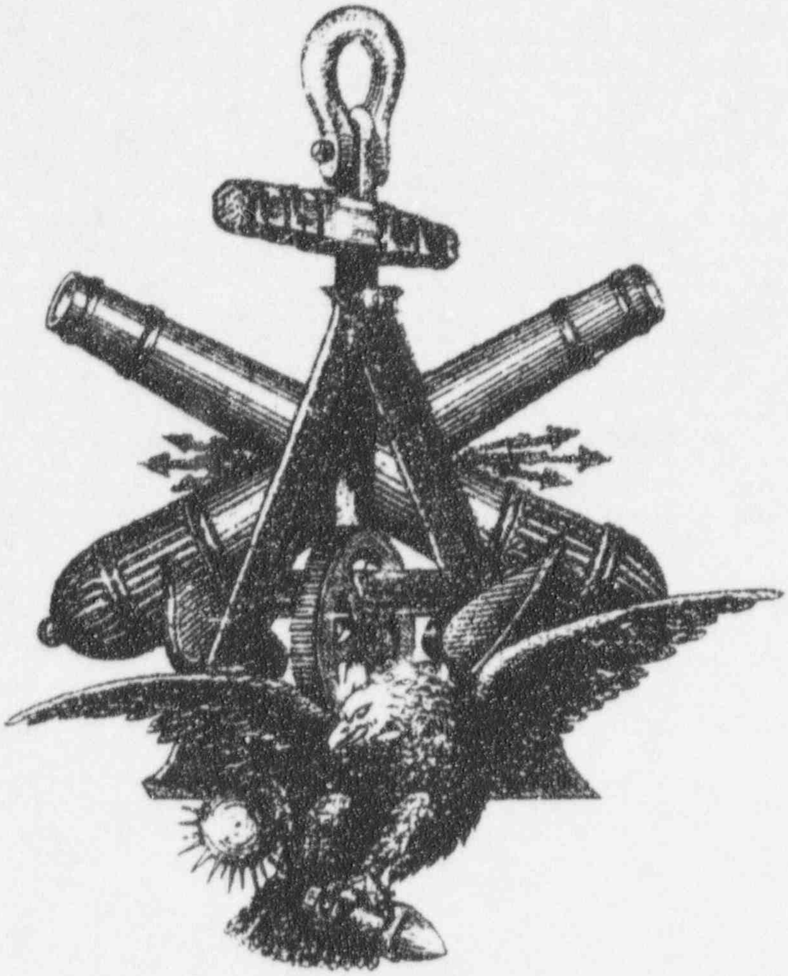
13.30 AP600 SPECIFIC DISCUSSIONS:
- QA PROCESS ON DESIGN AND CONTRUCTION OF MODIFICATIONS TO VAPORE FACILITY FOR AP600 PHASE A AND PHASE B TESTING
- QA INTERFACE FOR RELAP CALCULATIONS ON SPES-2

16.00 COFFEE BREAK

16.15
- PROCESS FOR DEVELOPMENT OF AS-BUILT DRAWINGS
- QA INTERFACE FOR OTHER ACTIVITIES RELATED TO AP600 (AS APPLICABLE) (e.g., RELAP CALCULATIONS ON SPES-2 AND POST-TEST DATA ANALYSIS)
- NRC SUMMARY OF AP600 OBSERVATIONS

March 12, 1996

09.00 SBWR SPECIFIC DISCUSSIONS
- Q.A. PROCESS ON DESIGN AND FABRICATION OF PANTHERS HEAT EXCHANGERS.
- NRC SUMMARY OF SBWR OBSERVATIONS



SOCIETA' ANONIMA ITALIANA.

GIO. ANSALDO & CO.

GENOA, (ITALY.)

AMERICAN BRANCH

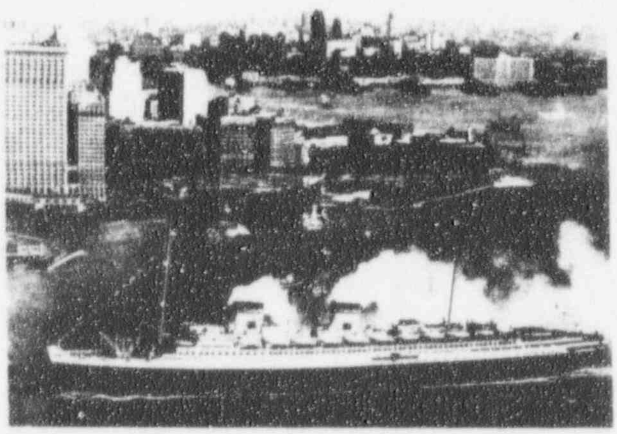
ANSALDO

Archivio Storico

ANSALDO AND THE UNITED STATES

The oldest Italian manufacturing company, Ansaldo was established in 1853. Among the many distinguishing features of its history there is an almost unique record of long-term association with the US business world. In fact, only an handful of Italian companies can claim a comparable tradition along this line.
As early as 1898, at the time of the Cuban war, there is evidence of a US naval official visiting the Ansaldo works in Genoa, in order to persuade the company to sell the US government a battle cruiser originally ordered by Spain. Because of the long standing commercial relations between the company and the Spanish government the American attempt failed. Yet the episode gives a clear idea that the ships sold by the firm over the decade 1894 - 903 were intended for foreign markets: Argentina, Spain, Turkey, Russia an Japan.
A few years later Ansaldo's path crossed again with America. The urgent need to purchase both armor plate and the related technological patents induced the Italian company to enter into protracted negotiations with two large US firms, Midvale and Bethlehem, between 1905 and 1910. Especially the latter at some point seemed on the verge of signing an important agreement with Ansaldo for the joint erection, under Bethlehem's license, of a new armor plate plant in Spain. Many problems, financial as well as diplomatic, prevented the agreement from taking place. Indeed this fact would have been quite a striking event, in view of the peculiar state of the economic relations between the two countries. In those days the United States represented the third commercial partner of Italy after Great Britain and Germany. But almost nothing was exchanged between the two countries in terms of steel products.
An American patent, however, was secured by Ansaldo a few years later, in 1913, when the Genovese company purchased the Wales & Reece patent for vanadium steel from Carnegie.
A relationship between the Genovese firm and the US developed on a systematic basis after Italy's entry into World War One. This was, in fact, a part of a more general nationwide trend: that is, the tendency, on the part of Italy, to turn increasingly to the US in search of raw materials and machinery.
In 1915, with the avowed goal of purchasing such products, Ansaldo established a permanent mission in New York. From Oct. 1915 to Oct. 1918 this resulted in an uninterrupted flow of purchases that were valued at over $44,000,000. At the same time there emerged a strong need for greater "visibility" among the American business and political circles, that could earn the Italian company easier access to needed materials. This urged Ansaldo to develop many devices, ranging from the adoption of a new symbol, especially designed for the American branch, with an "American" eagle added to the traditional sign, to an extensive use of such media as papers, technological journals, and documentary films. Thus Ansaldo was described by the **Philadelphia Saturday Evening** as the "Krupp of Italy" and its top manager Pio Perrone as the "Latin prototype of the Carnegies and the Schwabs of America".
Shortly after the armistice was signed, the company capitalized on the articulated network of contacts established during this period, in order to try any possible opening offered by North and South American markets to such Ansaldo products as the motorboat engines S. Giorgio and the military planes Balilla and SVA. And in the course of a couple of years at least eleven SVA and five Balilla, plus several S. Giorgio engines, were sold in the US.
In this connection in 1920 the American Society of Mechanical Engineers (ASME) accorded its honorary membership to Pio Perrone as the leading representative of Italian industrial ingenuity during the war. That explains why Mr. Perrone was the only Italian in the "gallery of worthies whose names are famous among engineers and whose lives are worthy of emulation" that the **Mechanical Engineering**, the ASME's official organ, carried in its fiftieth anniversary special issue in 1930. Incidentally, it seems worthwhile quoting at least a few illustrious names included in the "gallery": Andrew Carnegie, Frederick Winslow Taylor, Henry Bessemer, Thomas Edison, Orville Wright, and Albert Parson.
The closing of the American branch almost coincided with the financial crack that sealed the fate of the Perrone family and forced Ansaldo's top management to resign late in 1921.
Yet America did not disappear from the company's horizon, if only because Agostino Rocca, the newly emerging top manager, who was to restore Ansaldo's fortune in the 1930s, was quite abreast of American new technological and organizational tools. In fact, he tried to apply some of them in order to reshape the Genovese company. Then, after World War Two, Ansaldo played an important role in the definite establishment of closer and more systematic commercial relations between the two countries. This process is still going on and even a cursory look at the present condition of Ansaldo's plants can give an adequate measure of its newest developments.

Visit of the American Trade Delegation to the factories of S.A.I. Gio. Ansaldo & C. - 1917



The "REX" arriving in New York harbor - 1932

Ansaldo Archivio Storico
Corso F.M. Perrone, 118 - 16161 Genova - Italia
Tel. 010-6551 - Telefax 010-441229 - Telex 216596

ANSALDO

COMPANY STRUCTURE 1994

Systems
Components
Service
Nuclear power

Cogeneration
Transmission and distribution

Electrical systems and automation

Transportation systems
Signalling Automation
Vehicles Power Supply

Technological systems
Information systems

ANSALDO

ANSALDO ENERGIA
- Ansaldo Gie
- Termosud
- F. Tosi Ingegneria

ANSALDO INDUSTRIA
- Ansaldo Bmb
- Ansaldo Loire Aut.
- Bmb / Ise
- Concol Systems
- Hill Graham Controls
- Ieg
- Microelettrica Scient. (*)
- Ansaldo Ross Hill
- Werfel
- Ansaldo Volund
- Sagem
- Ansaldo Ind. of America
- Ansaldo Tecnitalia
- Aerimpianti
- Semagiotto

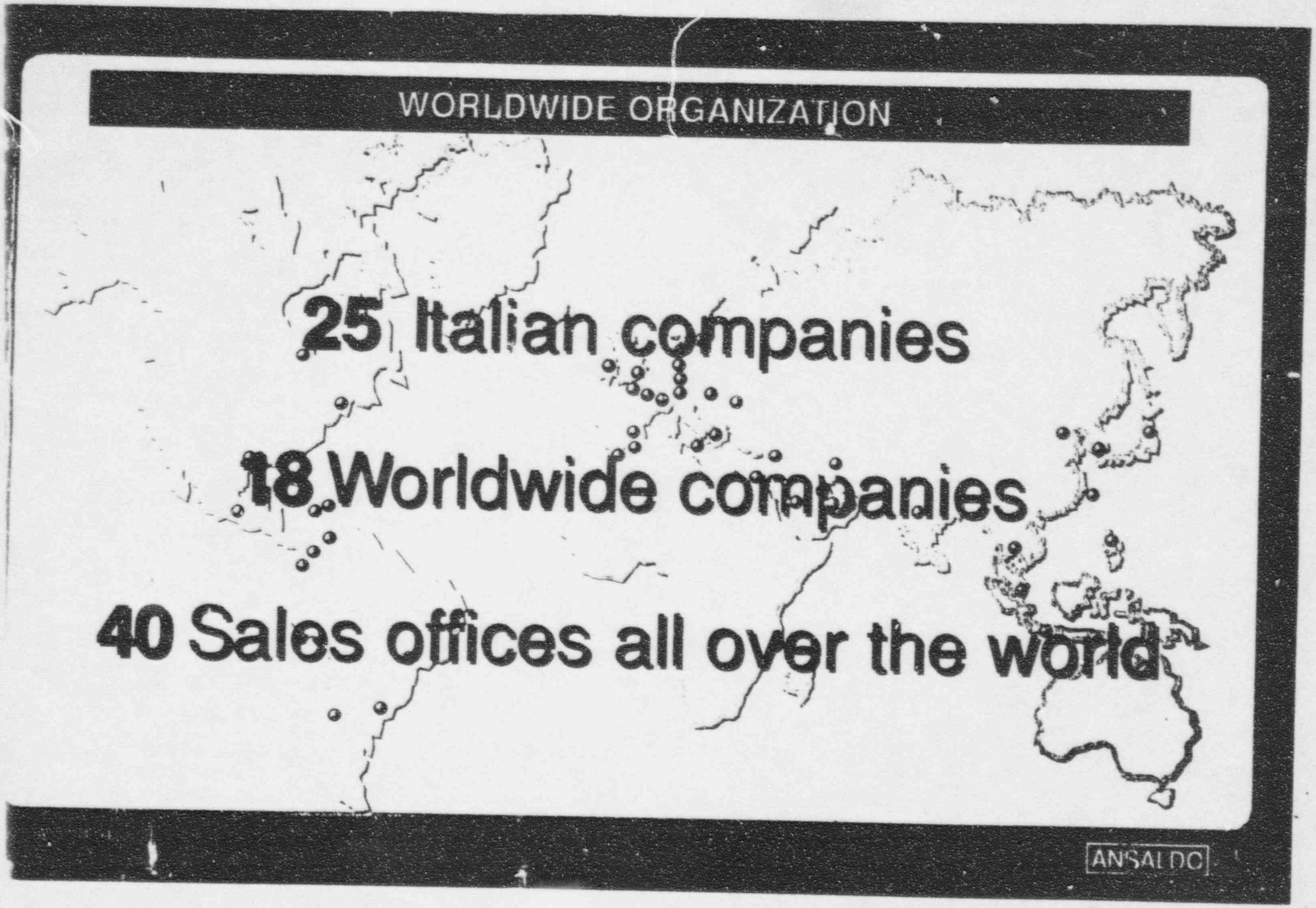
ANSALDO TRASPORTI
- At Signalling
- At Signal System
- Case Transport (*)
- Firema (*)
- Segnalamento Ferr.
- Transystem
- Union Switch & Signal

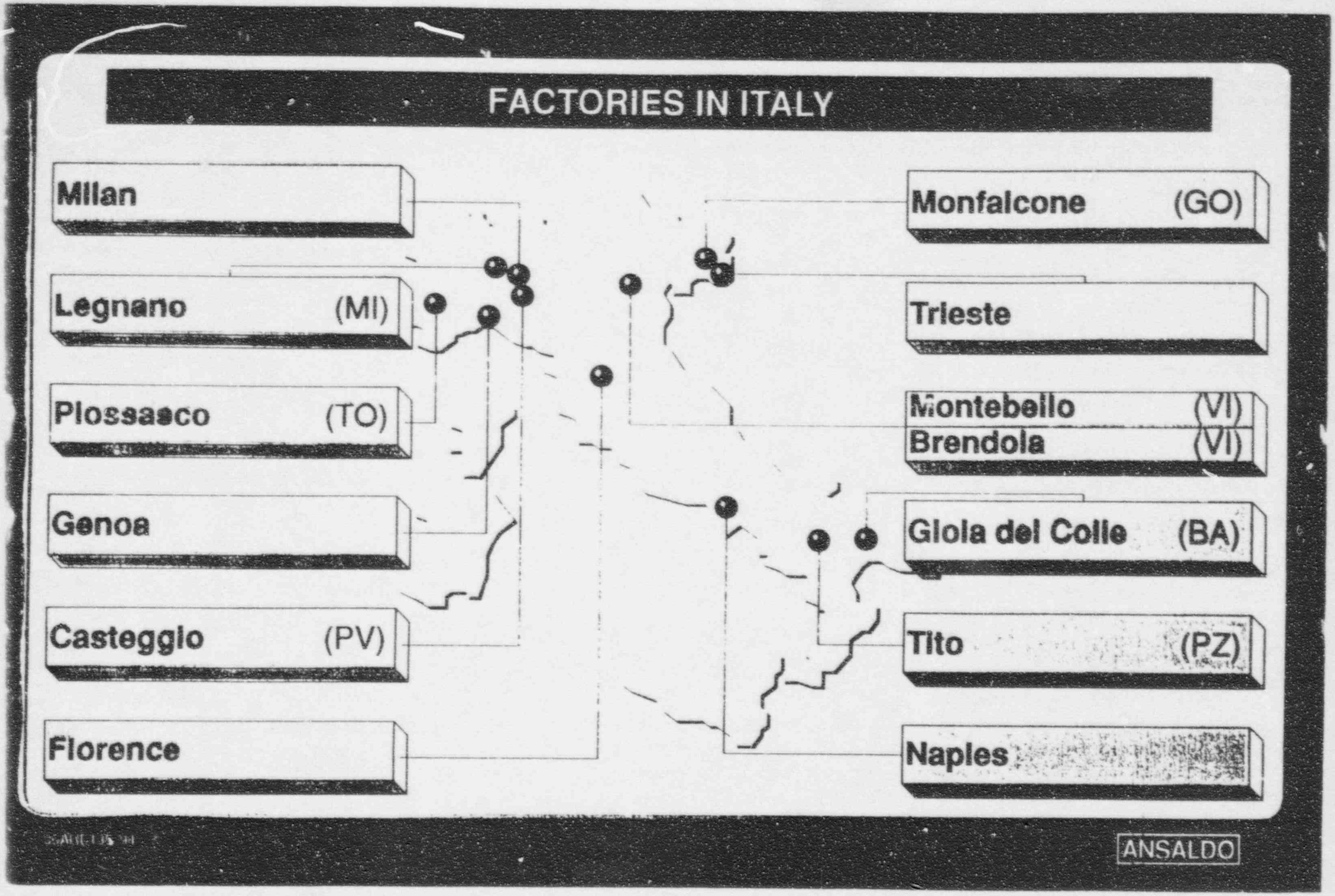
- Ansaldo International
- Asi
- Ceaen
- Sni
- Ansaldo Ricerche
- Anit
- Cic
- Coemsa Ansaldo
- Ganz Ansaldo
- Sopren

—— Energy
—— Industry
—— Transportation
Support activities and other

(*) Minority shareholdings

ANSALDO


WORLDWIDE ORGANIZATION
25 Italian companies
18 Worldwide companies
40 Sales offices all over the world
ANSALDO


FACTORIES IN ITALY
Milan
Legnano (MI)
Plossasco (TO)
Genoa
Casteggio (PV)
Florence
Monfalcone (GO)
Trieste
Montebello (VI)
Brendola (VI)
Giola del Colle (BA)
Tito (PZ)
Naples
ANSALDO

NUCLEAR DIVISION

THE MISSION:

- REAFFIRM THE ROLE OF PRIMARY INTERNATIONAL COMPANY IN NUCLEAR TECHNOLOGY SUPPLIES.

- CONTRIBUTE TO REVIVE THE NUCLEAR OPTION IN ITALY AS LEAD INDUSTRIAL PARTNER.

NUCLEAR DIVISION

MAIN NUCLEAR PRODUCT LINES:

NEW REACTORS STUDIES:

- AP 600
- SBWR
- EPP
- ISIS

SERVICE AND CONSTRUCTION:

- CERNAVODA
- SPX
- VVER (Kozloduy, Temelin, Kola, Novoronetz)

FABRICATION UCN:

- PCC, IC (SBWR)
- IHX (SPX)
- SPENT FUEL CASKS (Germany)
- STEAM GENERATORS

ANSALDO

NUCLEAR DIVISION

OTHER PRODUCT LINES

HI-TECH PRODUCTS:

- HANDLING MACHINES AND TELEOPERATION
- PLANT SIMULATORS
- EXPERT SYSTEMS FOR OPERATOR AID
- TEST REACTORS FOR NUCLEAR RESEARCH

SERVICES:

- PLANT LIFE EXTENSION
- RISK ASSESSMENT
- QUALITY MANAGEMENT

NUCLEAR DIVISION

P. VALENTINI
R. ADINOLFI

BUSINESS DEVELOPMENT
F. BIAGIOLI

QUALITY ASSURANCE
A. PEDEMONTE

MARKETING AND SALES
G. VILLA

SERVICES:
- PROCUREMENT
- EDP
- COST CONTROL

CERNAVODA PROJECT
P. MERLO

ADVANCED REACTORS PROJECT AND NUCLEAR SERVICES
E. DI CAPUA

SYSTEM ANALYSIS
H. SIMONOT

CORE DESIGN SAFETY ANALYSIS
G. PROTO

COMPONENT DESIGN AND PLANT LAY-OUT
F. L. RIZZO

HANDLING MACHINES AND TELEOPERATIONS
G. SCROFANI

ANSALDO

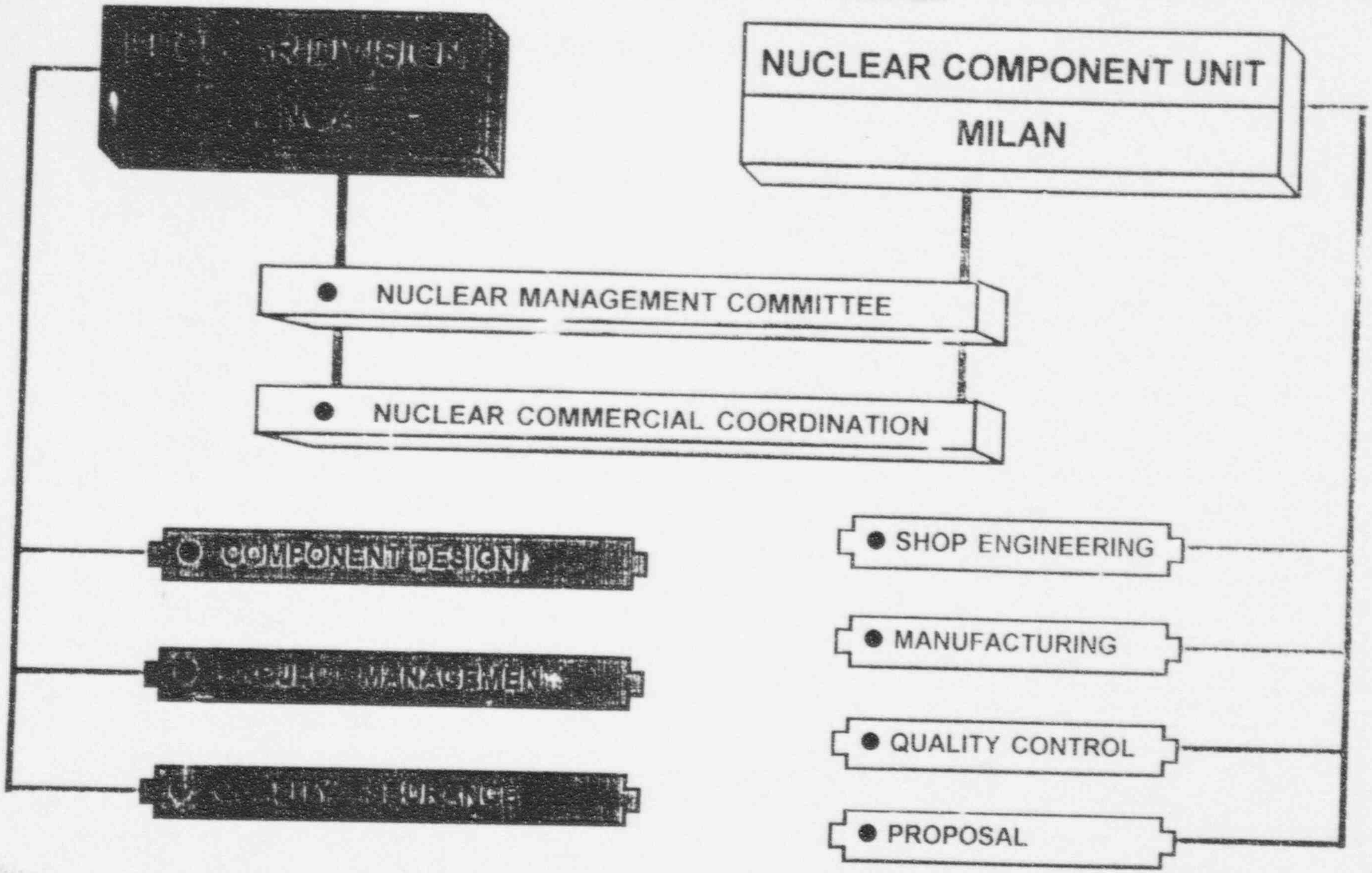
NUCLEAR DIVISION

ENGINEERING CAPABILITIES

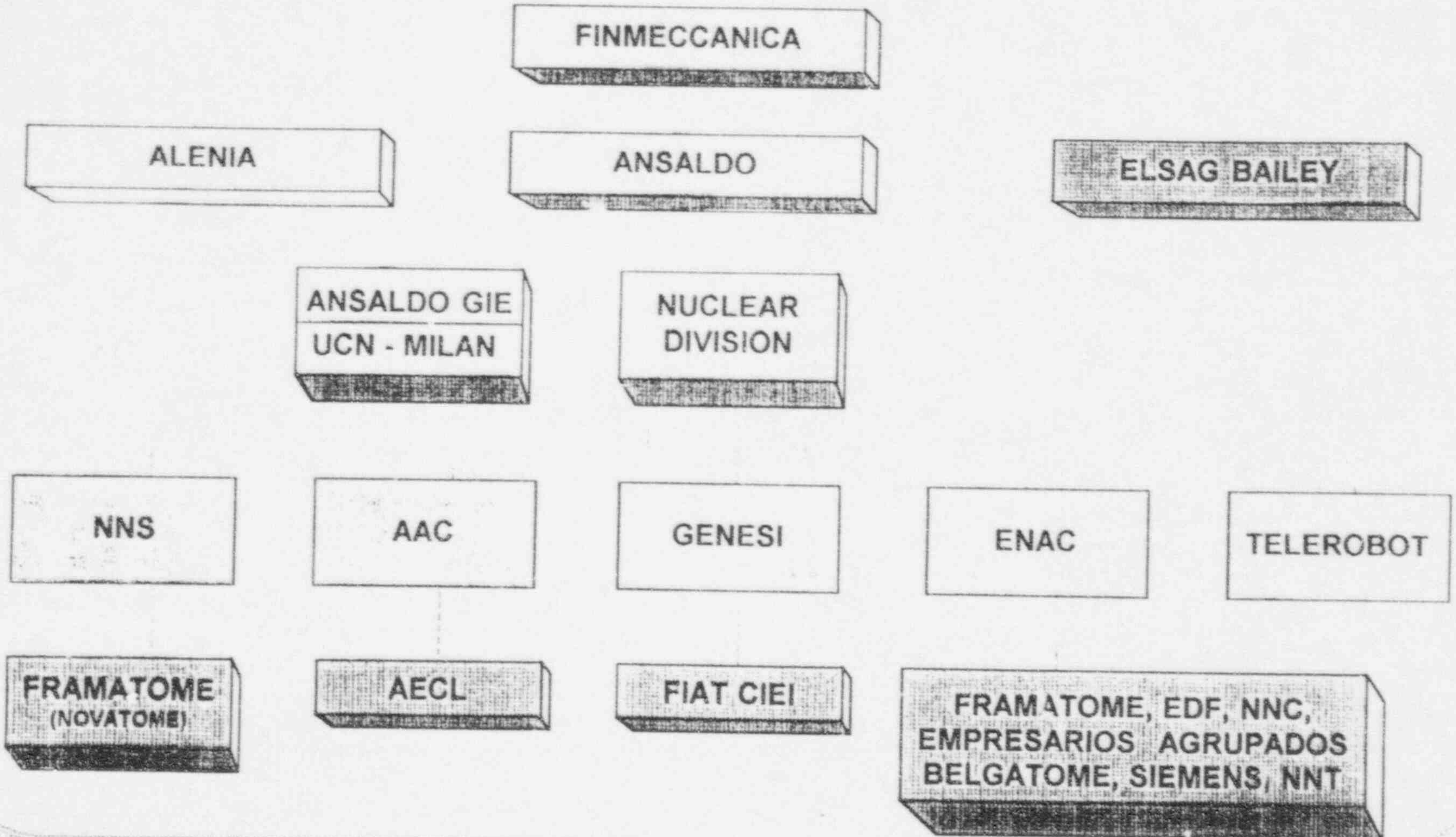
- SYSTEM DESIGN
- SAFETY & RELIABILITY ANALYSIS
- MECHANICAL COMPONENTS DESIGN
- GENERAL PLANT ARRANGEMENT & PLANT LAY-OUT
- ELECTRICAL SYSTEMS
- INSTRUMENTATION & CONTROL
- SEISMIC & STRUCTURAL ANALYSIS
- THERMOHYDRAULICS
- RADIATION PROTECTION
- CORE DESIGN
- PLANT SIMULATION
- REMOTE HANDLING

by I.B. - DNU/QUA

ANSALDO ORGANIZATION



NUCLEAR DIVISION



by I.B. - DNU/QUA

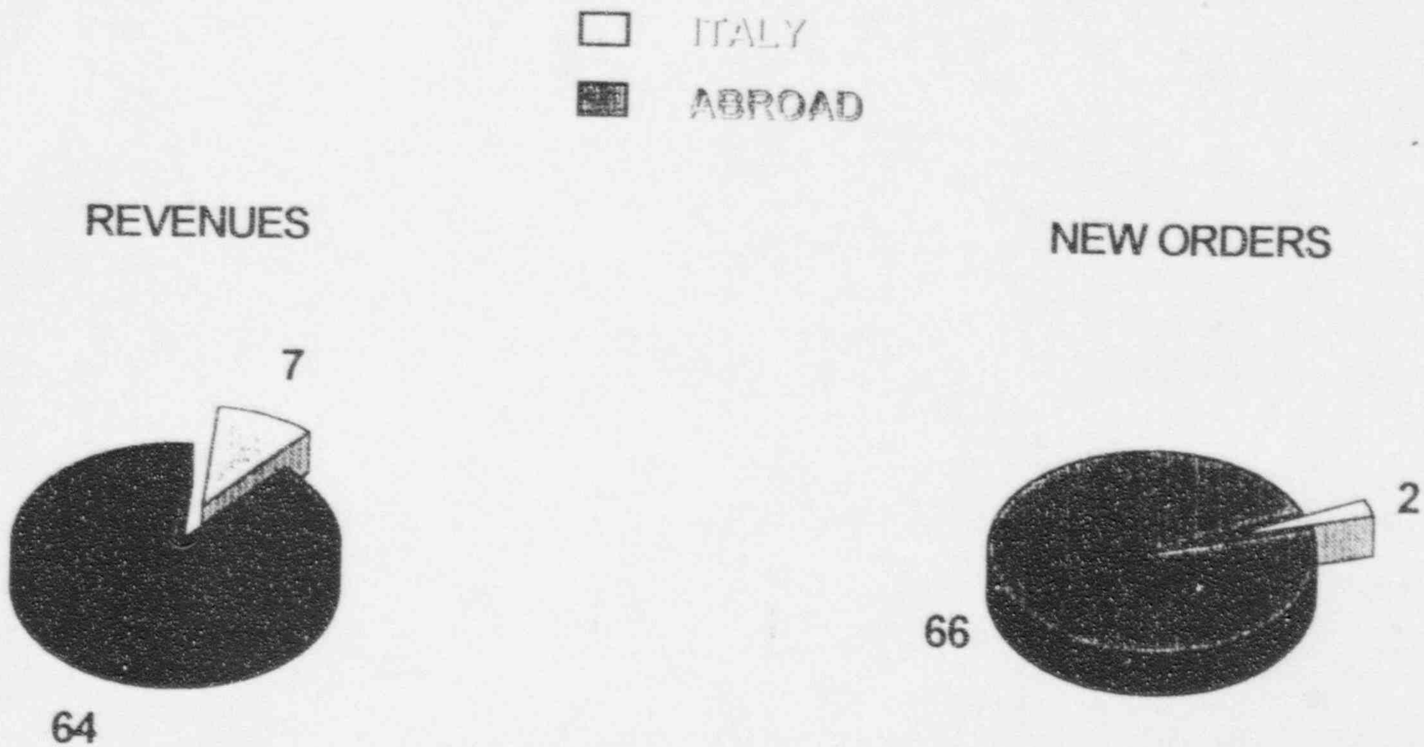
NUCLEAR DIVISION

MAIN DATA FOR THE YEAR 1994

- PERSONNEL 212
- REVENUES BILLION - LIRE 71
- NEW ORDERS BILLION - LIRE 68

ANSALDO

NUCLEAR DIVISION



NUCLEAR DIVISION

NEW REACTORS STUDIES:

- AP 600
- SBWR
- EPP
- ISIS

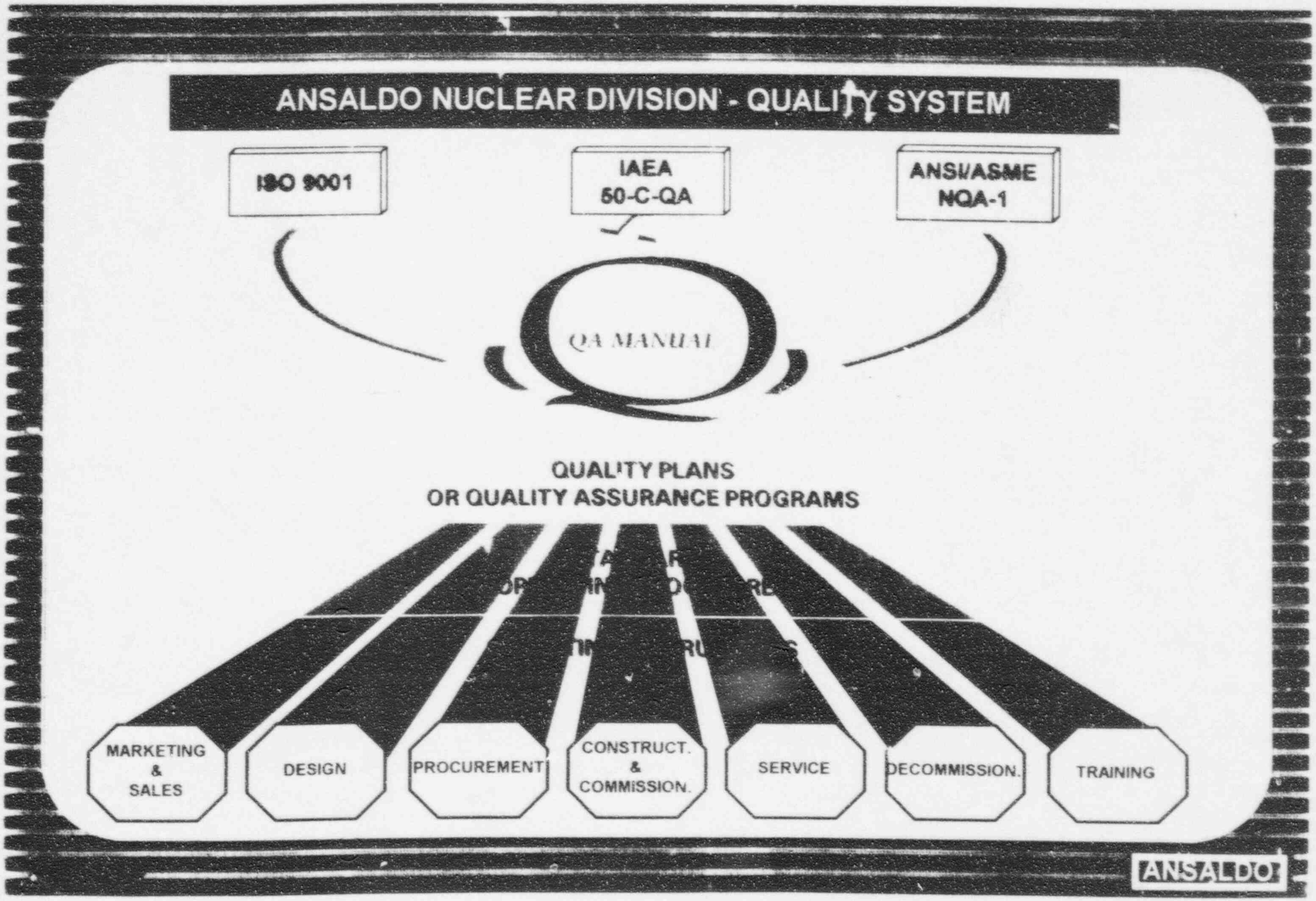
SERVICE AND CONSTRUCTION:

- CERNAVODA
- SPX
- VVER (Kozloduy, Temelin, Kola, Novovoronetz)

FABRICATION UNIT:

- PCC, IC (SBWR)
- IHX (SPX)
- SPENT FUEL CASKS (Germany)
- STEAM GENERATORS

ANSALDO


ANSALDO NUCLEAR DIVISION - QUALITY SYSTEM
ISO 9001
IAEA 50-C-QA
ANSI/ASME NQA-1
QA MANUAL
QUALITY PLANS
OR QUALITY ASSURANCE PROGRAMS
MARKETING & SALES
DESIGN
PROCUREMENT
CONSTRUCT. & COMMISSION.
SERVICE
DECOMMISSION.
TRAINING
ANSALDO

0. GENERALITY

0.1 TABLE OF CONTENTS

SECTION 15: NON-CONFORMING PLANT PARTS **Rev. 3.**

SECTION 16: CORRECTIVE ACTIONS **Rev. 2.**

SECTION 17: QUALITY ASSURANCE DOCUMENTATION **Rev. 2.**

SECTION 18: AUDITING **Rev. 3.**

APPENDIX 1: PROCEDURES LIST **Rev. 0**

0.2. MANAGEMENT'S STATEMENT

The Nuclear Division Management of "ANSALDO un'Azienda Finmeccanica S.p.A." has defined a Quality Assurance Programme (Q.A.P.), as described in this present Manual, in order to assure the correct performance of the activities related to design, construction and start-up of structures, systems and components relevant with regard to Nuclear Safety and Radiation Protection, and their satisfactory operation.
The requirements of this Manual are also applicable, to the extent required by the project, for the activities related to the nuclear plants decommissioning and to the supply of non-nuclear plants or products pertaining to the Nuclear Division (DNU).
Ansaldo Nuclear Division Management has the responsibility for the application of the Q.A.P. The Q.A. Department Manager has the responsibility of verifying the efficiency, adequacy and correct implementation of the Q.A. Programme.
The management has also defined the tasks and responsibilities of the departments concerning the application of Q.A.P., the methods by which procedures shall be operated, and the degree of application of each single part of the Programme to be allocated to the various departments concerned.
In particular, the Quality Assurance Department is charged by the Management with the Q.A.P. definition; in particular the former reports directly to the Nuclear Division Management, thus assuring the required independence.
It is therefore intended that Q.A. personnel has the responsibility and the autorithy to identify problems and suggest and follow-up solutions defined within the organizational framework concerned.
The Nuclear Division Management also sets the information instruments regarding the qualitative trend of the activities; particularly, the Quality Assurance Department must inform the Management sistematically about the observance and efficiency of the QA program.

The Nuclear Division Manager

0.3 TABLE OF COMPARISON BETWEEN QAM AND REGULATION EN29001

English translation of ISO 9001

Subjects Title	Chapter EN 29001	QAM Corresponding chapter
Management's Responsibilities	4.1	0.2. - 1.
Quality System	4.2	2.
Contract review	4.3	2.6.1
Verification of the design	4.4	3.
Verification of the documentation	4.5	6.
Procurement	4.6	4. - 7.
Products supplied by the customer	4.7	7.7
Identification and traceability of the products	4.8	8.
Verification of the production process	4.9	9.
Tests and inspections	4.10	10. - 11.
Testing and measurement equipment	4.11.	12.
Status of inspections and tests	4.12	14.
Non-conforming products inspection	4.13	15.
Corrective actions	4.14	16.
Handling, packing, storage and delivery	4.15	13.
Quality Assurance records	4.16	17.
Quality Assurance internal audits	4.17	18.
Training	4.18	2.8.
Assistance	4.19	(1)
Statistics	4.20	(2)

(1) DNU performs assistance and service activities within the contractual limits and in accordance with the established procedures complying with this QAM.

(2) When necessary, the suitable techniques are detected and regulated by proper procedures, if needed.

ANSALDO
Un'Azienda Finmeccanica
DIVISIONE NUCLEARE

PROGRAMMA GLOBALE VERIFICHE ISPETTIVE INTERNE

ANNO 1995

ENTE	PROGETTO CONTRATTO	RGVI	Ente di supporto	GEN		FEB		MAR		APR		MAG		GIU		LUG		AGO		SET		OTT		NOV		DIC		NOTE
				I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	
ANH	VARI	Arena							☐																			Audit di sistema
CER	CER 1	Arena										☐																
CNU	VARI	Marsano																			☐							Audit di sistema
IMP	CER 1	Arena											☐															
IMP	FOAKE	Marsano						☐																				
IMP	Kozloduy	Marsano				▲																						
IMP	SPX 1	Arena								☐																		
MTL	SPX 1	Sala B.							☐																			
MTL	VARI	Arena									☐																	Audit di sistema
NEA	FOAKE	Marsano										☐																
NEA	SA1	Sala B													☐													
NRS	FOAKE	Marsano					☐																					
NRS	SPX 1	Sala B.						☐																				
SIS	CER 1	Arena								☐																		
SIS	FOAKE	Marsano								☐																		
SIS	Kozloduy	Marsano				▲																						
SIS	SPX 1	Sala B.														☐												
STR	FOAKE	Marsano												☐														

V.I. NON PROGRAMMATA — ☐ V.I. PROGRAMMATA

▲ V.I. EFFETTUATA RAC EMESSA/E — ◢ V.I. EFFETTUATA RISP. A RAC ACCET. — RICH. AZIONE DI FOLLOW-UP — ■ V.I. COMPLETATA CLOSE-UP

REDAZIONE	APPROVAZIONE
MARSANO	PEDEMONTE
DATA 18/1/95	DATA 3/2/95

ANSALDO
Un'Azienda Finmeccanica
DIVISIONE NUCLEARE

PROGRAMMA GLOBALE VERIFICHE ISPETTIVE INTERNE

ANNO 1995

ENTE	PROGETTO CONTRATTO	RGVI	Ente di supporto	GEN.		FEB.		MAR.		APR.		MAG.		GIU.		LUG.		AGO.		SET.		OTT.		NOV.		DIC.		NOTE
				I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	
ANH	VARI	Arena							V.I. effettuata RAC emesse																			
CER	CER 1	Arena										V.I. effettuata RAC emesse																Audit di sistema
CNU	VARI	Marsano																				V.I. completata						
IMP	CER 1	Arena											V.I. programmata															Audit di sistema
IMP	FOAKE	Marsano						V.I. effettuata RAC emesse			Rich. azione di follow-up					V.I. completata												
IMP	Kozloduy	Marsano				V.I. effettuata RAC emesse				Rich. azione di follow-up	V.I. completata																	
IMP	SPX 1	Arena								V.I. programmata																		
MTL	SPX 1	Sala B.							V.I. effettuata RAC emesse													Rich. azione di follow-up						
MTL	VARI	Ar[illegible]									V.I. effettuata RAC emesse											Rich. azione di follow-up						
NEA	FOAKE	Marsano										V.I. effettuata RAC emesse				Rich. azione di follow-up				V.I. completata								Audit di sistema
NEA	SA1	Sala B.													V.I. programmata													
NRS	FOAKE	Marsano					V.I. completata																					
NRS	SPX 1	Sala B.						V.I. programmata		V.I. completata																		
SIS	CER 1	Arena								V.I. programmata																		
SIS	FOAKE	Marsano								V.I. completata																		
SIS	Kozloduy	Marsano				V.I. effettuata RAC emesse						V.I. completata																
SIS	SPX 1	Sala B.														V.I. programmata												
STR	FOAKE	Marsano												V.I. effettuata RAC emesse			Rich. azione di follow-up					V.I. completata						

V.I. NON PROGRAMMATA — V.I. PROGRAMMATA

V.I. EFFETTUATA RAC EMESSE — V.I. EFFETTUATA RISP. A RAC ACCET. — RICH. AZIONE DI FOLLOW-UP — V.I. COMPLETATA CLOSE-UP

REDAZIONE	APPROVAZIONE
MARSANO	PEDEMONTE
DATA 18/1/95	DATA 3/2/95

AUDITS MADE BY :

GENERAL ELECTRIC :

I^ 15/10/1990 No CAR Issued

II^ 27/09/1993 No CAR Issued

WESTINGHOUSE :

I^ 15-16/07/1991 Issued n. 1 N.C. and n. 5 OBS

II^ 25-26/02/1993 Issued n. 3 N.C. and n. 2 OBS

III^ 24-26/10/1995 No findings

RAG.SOCIALE	LOCALITA	NAZ	SIS.QUA	MERC.	DESCRIZIONE	ESITO ISP.QUA. Q G - DETTAGLIO	VERBALF	D.VISITA	D.SCAD.	M*NUALE QUALITA	/ REV.
ABB ADDA S.P.A.	LODI	- I	ISO-9001	MC	-COMPONENTISTICA DA QUADRO	C R -					/
ABB ELETTROCONDUTTURE S.P.A.	MILANO	- I	ISO-9001	NAC	-Interr :tori AT (SF6 - ar	C R -					/
ABB INDUSTRIA S.p.A. Filiale di GENOVA	GENOVA	- I	ISO-9001	PIA	-Sistemi integrati di auto	C R -					/
ABB INDUSTRIA SPA	SESTO S.GIOVANNI	- I	ISO-9001	LF	-ALTRI COMPONENTI ELETTRIC	C R -					/
				MD	-STRUMENTAZIONE LOCALE E A	C R -					/
ABB KENT-TAYLOR S.P.A.	LENNO	- I	ISO-9001	IG	-VALVOLE DI REGOLAZIONE	C R -					/
				MAE	-Quadri regolazione	C R -					/
				MAK	-Banchi, cofani e cassette	C R -					/
				MB	-STRUMENTAZIONE DA QUADRO	C R -					/
				MD	-STRUMENTAZIONE LOCALE E A	-					/
				MDF	-Trasmettitori di pression	-					/
				MDG	-Trasmettitori di posizion	-					/
				MDH	-Trasmettitori di livello	-					/
				MDL	-Regolatori locali	-					/
				MEA	-Strumenti per analisi	-					/
				PI	- SISTEMI DI AUTOMAZIONE E	-					/
				PIB	-Sistemi di regolazione e						/
ADVEL ELETTRONICA INDUS.LE SRL	SEGRATE	- I	ISC 9002	N	-APPARECCHIATURE ELETTRICH	C -					/
AG:A GEVAERT SPA	MILANO	- I	ISO-9002	DOF	-Macchine ed attrezzature	-					/
ALCATEL CAVI SPA	COLOGNO MONZESE	- I	ISO-9002	LAI	-Cavi per telecomunicazion	C R -					/
				LAK	-Cavi speciali (navali, po	C R -					/
ALCATEL DIAL FACE SPA	MILANO	- I	ISO-9001	7B	-NOLEGGIO MACCHINE DA UFFI	-					/
				LDI	-Telefax	C R -					/
ALGA SPA	MILANO	- I	ISO-9002	ICA	-Supporti elastici a caric	C R -					/
ANSALDO AZ.FINM.DIV.DNU	GENOVA	- I	ISO-9001	1F	-PROGETTAZIONI SISTEMISTIC	1 Q -	PQA-95-383	02/11/95		A-M-DNU-001	/ 5
				2F	-ATTIVITA' DI SUPERVISIONE	1 Q -				A-M-DNU-001	/ 5
ANSALDO COMPONENTI S.R.L.	MILANO	- I	ISO-9001	3	-CALDARERIA	1 Q -				COPIA CONTROLLA.103	/ 23
				H	-APPARECCHIATURE DI SCAMBI	1 Q -					/ 23
ANSALDO ENERGIA SPA	GENOVA (CORNIGLI	- I	ISO-9001	OAA	-Generatori in c.a. (esclu	C Q -					/
				OAB	-Generatori in c.c.	C Q -					/
				QBA	-Turbogruppi a vapore	C Q -					/
				QBB	-Turbogruppi a gas	C Q -					/
ANSALDO INDUSTRIA SPA	GORIZIA	- I	ISO-9001	LF	-ALTRI COMPONENTI ELETTRIC	C R -				SEZIONI "A" E "C"	/ 6
				NAC	-Interruttori AT (SF6 - ar	-					/
AUSONIA SRL	MARSALA	- I	ISO-9002	OAA	-Generatori in c.a. (esclu	C R -					/
BELLELI S.P.A.	MANTOVA	- I	ISO-9001	1B	-PROGETTAZIONI MECCANICHE	1 Q - 2Q-3Q-4Q	RVA 04/91	18/12/91	17/12/94	MQQ 01 E QAM 05	/ 2
				3B	-MONTAGGI MECCANICI	-					/
				3BA	-Montaggi di caldaia ed au	-					/
				AC	-TUBI IN CANNE DIRITTE	-					/
				F	-STRUTTURE METALLICHE E CO	-					/
				G	-CALDARERIA	-					/
				GD	-SERBATOI A PRESSIONE ATMO	-					/
				GE	-SERBATOI ED INVOLUCRI IN	-					/
				H	-APPARECCHIATURE DI SCAMBI	-					/
				HC	-PRERISCALDATORI ACQUA ALI	-					/
				HH	-SCAMBIATORI A PIASTRE E R	-					/
				HK	-BATTERIE DI SCAMBIO TERMI	-					/
				PO	-IMPIANTI E SISTEMI PER CE	-					/
				POF	-Generatori di vapore nucl	-					/

R.SOCIALE	LOCALITA	NAZ	SIS.QUA	MERC.	DESCRIZIONE	ESITO ISP.QUA Q G - DETTAGLI	VERBALE	D.VISITA	D.SCAD.	MANUALE QUALITA / REV.
RREDI SPA	GE-SAMPIERDARENA	- I	ISO-9002	EA	-MACCHINE UTENSILI	-				/
				EF	-ATTREZZI	-				/
				IM	-GUARNIZIONI, ANELLI DI TE	-				/
DROCCHI SRL	BIASSONO	- I	ISO-9001	H	-APPARECCHIATURE DI SCAMBI	C R -				/
				HAZ	-Condensatori di altro tip	-				/
				HB	-TORRI EVAPORATIVE	-				/
				HF	-SCAMBIATORI A FASCIO TUBI	-				/
				HFA	-Scambiatori a fascio tubi	-				/
				HI	-AERGTERMI	-				/
				JG	-VENTILATORI E SOFFIANTI (	-				/
				JGB	-Altri ventilatori centrif	-				/
				JGD	-Altri ventilatori assiali	-				/
				JGE	-Soffianti	-				/
				JGF	-Torrini di estrazione	-				/
				PBF	-Imp. di depolverazione	-				/
				PCA	-Imp. ventilazione e condi	-				/
SRL	MELE	- I	ISO-9002	SK	-LAVORAZIONI ELETTRICHE ED	-				/
				NA	-QUADRI STRUMENTAZIONE E C	-				/
				NBE	-Quadri TV, quadri centra	-				/
				NCB	-Quadri power center	-				/
				NCC	-Quadri motor control cent	-				/
				NCD	-Quadri sottodistribuzione	-				/
				NJQ	-Schede	-				/
				PI	- SISTEMI DI AUTOMAZIONE E	-				/
Caldereria-Carpenteria-Meccanica s.r	Amelia	- I	ISO-9003	F	-STRUTTURE METALLICHE E CO	C R -	2DI/042	16/03/93	16/03/96	/
				G	-CALDARERIA	C R -				/
				P	-IMPIANTI E SISTEMI PACKAG	C R -				/
A S.P.A.	SAN MARTINO DI B	- I	ISO-9002	MD	-STRUMENTAZIONE LOCALE E A	C P -				/
				MDC	-Pressostati	C R -				/
				MDD	-Termostati	C R -				/
				MDZ	-Altri strumenti (dinamo t	C R -				/
ESA	COUR-CHEVERNY	- F	ISO-9002	I	-COMPONENTI MECCANICI	4 Q -	RVA003/93	16/09/93	15/09/96	/
S.A. BOCSA	BOCSA	- R	ISO-9002	F	-STRUTTURE METALLICHE E CO	2 R - 3Q-4Q	RVA 00'/95	29/11/95	28/11/98	MC-BAC-02 / 0
				FA	-CARPENTERIE E STRUTTURE P	2 R - 3Q-4Q	RVA005/95	29/11/95	28/11'98	MC-BAC-02 / 0
				FAA	-Carpenterie e strutture p	2 R - 3Q-4Q	RVA 005/95	29/11/95	28/11/98	MC-BAC-02 / 0
				FAB	-Carpenterie e strutture p	2 R - 3Q-4Q	RVA 005/95	29/11/95	28/11/95	MC-BAC-02 / 0
				FAF	-Casse a spirale per turbi	2 R - 3Q-4Q	RVA 005/95	29/11/95	28/11/98	MC-BAC-02 / 0
				FB	-CARPENTERIE E STRUTTURE M	2 R - 3Q-4Q	RVA 005/95	29/11/95	28/11/98	MC-BAC-02 / 0
				FC	-CARPENTERIE E STRUTTURE L	2 R - 3Q-4Q	RVA 005/95	29/11/95	28/11/98	MC-BAC-02 / 0
				FCB	-Scale, passerelle e ringh	2 R - 3Q-4Q	RTA 005/95	29/11/95	28/11/98	MC-BAC-02 / 0
				FCC	-Grigliati	2 R - 3Q-4Q	RVA 005/95	29/11/95	28/11/98	MC-BAC-02 / 0
				FCF	-Piastre e maschere di fon	2 R - 3Q-4Q	RVA 005/95	29/11/95	28/11/58	MC-BAC-02 / 0
				FCG	-Camini metallici	2 R - 3Q-4Q	RVA 005/95	29/11/95	28/11/98	MC-BAC-02 / 0
				FEA	-Condotte aria e fumi	2 R - 3Q-4Q	RVA 005/95	29/11/95	28/11/98	MC-BAC-02 / 0
				JI	- APPARECCHIATURE PER IMP	2 R - 3Q-4Q	RVA 005/95	29/11/95	28/11/98	MC-BAC-03 / 0
I INDIVIDUALE QUADRACCIA MARIO	TERNI	- I	ISO-9001	3B	-MONTAGGI MECCANICI	C R -				/
				S	-LAVORAZIONI E TRATTAMENTI	-				/
				NCD	-Quadri sottodistribuzione	-				/
BAILEY UN'AZIENDA FINMECCANICA SPA	GENOVA	- I	ISO-9001	D	-MATERIALI E PRODOTTI DIVE	-				/

ANSALDO GIE Stabilimento MILANO	ELENCO FORNITORI QUALIFICATI PER SCAMBIATORI PCCS & ICS *QUALIFIED VENDOR LIST FOR "PCCS & ICS" HEAT ECHANGERS (SBWR)*								EFQ
No. ITEM	FORNITORE	CAT.	LOCALITA'	QUALIFICA ASME (O EN 29002) *ASME O EN 29002 QUALIFICATION*		QUALIFICA ANSALDO GIE/MI *ANSALDO GIE QUALIFICATION*			SCOPI E LIMITI DELLA QUALIFICA
ITEM No.	*VENDOR*	*CAT.*	*LOCATION*	No CERT *CERT. No*	SCADENZA *EXPIRAT.*	No EAR *EAR No*	EMESSIL *ISS'D ON*	SCADENZA *EXPIRAT.*	*SCOPE & LIMITS OF THE QUALIFICATION*
1	DALMINE TUBI INDUSTR. S.r.l.	MM	BERGAMO (ITALY)	EN 29002	20.02.97				STEEL SEAMLESS TUBES (Manual according ASME NCA 3800)
	E.T.C. ELETTROTERMOCHIMICA	MM	PADOVA (ITALY)	EN 29002 (LRQA)	06.07.97				ARC WELDING ELECTRODES
3	FOMAS	MM	OSNAGO (CO) (ITALY)	QSC 273 EN 29002 (DNV)	06.07.97 15.03.95				FERROUS NONFERROUS FORGINGS & SEAMLESS TUBULAR PRODUCTS
4	FORGIATURA MORANDINI	MM	CIVITATE CAMUNO (BS) (ITALY)	EN 29002 (RINA)	06.11.95				CARBON,LOW AND HIGH ALLOY STEEL FORGINGS AND STAINLESS STEEL FORGINGS
5	FORGITAL SPEZZAPRIA	MM	SEGHE DI VELO (VI) (ITALY)	EN 29002	MAY. 97	EAR 291	26.02.93	26.02.94	FORGED ITEMS,ROLLED RINGS IN CARBON AND STAINLESS STEELS,ALLOY & SUPERALLOY
6	NUOVA TERMICS	MS	CREMONA (ITALY)	= =	= =	SCH.TEC. N. 02	21.07.93	21.07.94	INSTALLATION ELECTRICAL INSTRUMENTATION (PENDENTE QUALIFICA DA PARTE I.M.Q.)

 Preparato da / Prepared by: AMMQ

ELENCO FORNITORI QUALIFICATI PER SCAMBIATORI PCCS & ICS
QUALIFIED VENDOR LIST FOR "PCCS & ICS" HEAT ECHANGERS (SBWR)

EFQ

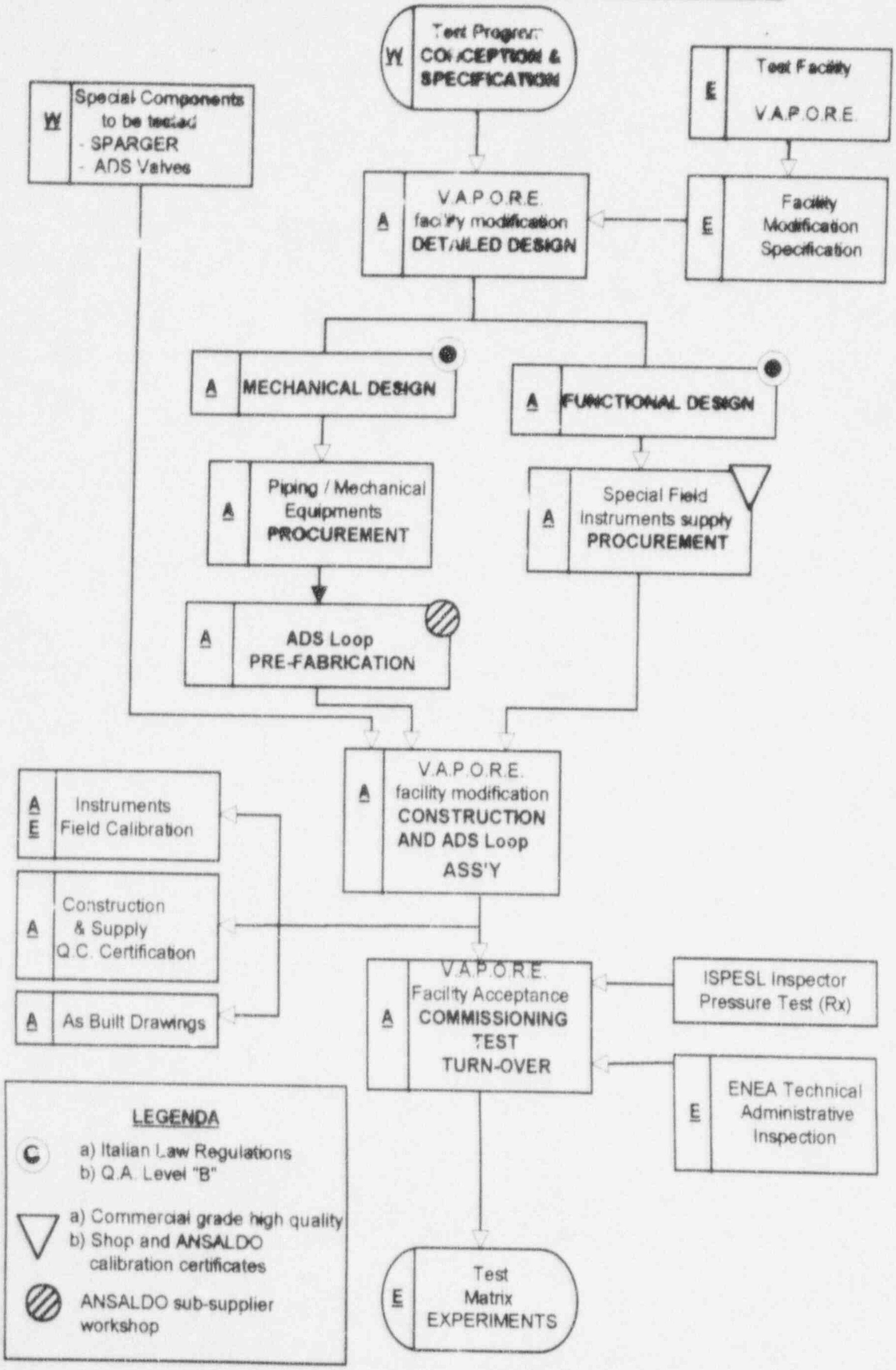
No. ITEM / *ITEM No.*	FORNITORE / *VENDOR*	CAT. / *CAT.*	LOCALITA' / *LOCATION*	QUALIFICA ASME (O EN 29002) / *ASME O EN 29002 QUALIFICATION*: No CERT. / *CERT. No*	SCADENZA / *EXPIRAT.*	QUALIFICA ANSALDO GIE/MI / *ANSALDO GIE QUALIFICATION*: No EAR / *EAR No*	EMES. IL / *ISS'D ON*	SCADENZA / *EXPIRAT.*	SCOPI E LIMITI DELLA QUALIFICA / *SCOPE & LIMITS OF THE QUALIFICATION*
7	O. C. S.	M	ALBIGNASEGO (PD) (ITALY)	S, U1	01.06.95	EAR 294 SCH.TEC N. 01	22.06.93 22.06.93	22.06.94 = =	EXCHANGE TUBES BENDING
8	O.M.E METALLURGICA ERBESE S.p.A.	MM	ERBA (COMO) (ITALY)	EN 29002 (D.N.V.)	11.11.95				MANUFACTURER OF BOLTING FOR NUCLEAR FIELDS (Manual according ASME NCA 3800)
9	T.A.D. COMMERCIALE	MS	LAINATE (MI) (ITALY)	EN 29002 (D.N.V.)	15.12.96	EAR 290	27.11.92	27.11.93	STOCKHOLDING OF PIPES,FITTINGS (WELDED AND SEAMLESS) HOLLOW BARS AND BARS OF STAINLESS STEEL
10	STERLING TUBES Ltd. ([redacted] of T.A.D.) Supplier	MM	CHESTERFIELD (ENGLAND)	EN 29002 (LL.RR.)	31.05.96				ALLOY AND STAINLESS STEEL AND HOT AND COLD FINISHED SEAMLESS STAINLESS STEEL TUBING
11	TOFREN MACCHINE	MS	SOLTO COLLINA (BG) (ITALY)	EN 29002 (LL.RR.)	30.06.96	EAR 292 EAR 293 EAR 295	15.03.93 03.09.93 11.10.93	15.03.94 03.09.94 11.10.94	FABRICATION OF INDUSTRIAL STEEL STRUCTURES TO CLIENT SPECIFICATIONS

 Preparato da / Prepared by: AMMQ

ANSALDO GIE Stabilimento MILANO	ELENCO FORNITORI QUALIFICATI PER SCAMBIATORI PCCS & ICS *QUALIFIED VENDOR LIST FOR "PCCS & ICS" HEAT EC..ANGERS (SBWR)*								EFQ
No. ITEM	FORNITORE	CAT.	LOCALITA'	QUALIFICA ASME (O EN 29002) *ASME O EN 29002 QUALIFICATION*		QUALIFICA ANSALDO GIE/MI *ANSALDO GIE QUALIFICATION*			SCOPI E LIMITI DELLA QUALIFICA
ITEM No.	*VENDOR*	*CAT.*	*LOCATION*	No CERT. *CERT. No*	SCADENZA *EXPIRAT.*	No EAR *EAR No*	EMES. IL *ISS'D ON*	SCADENZA *EXPIRAT.*	*SCOPE & LIMITS OF THE QUALIFICATION*
12	VALINOX. (NUCLEAR DIVISION)	MM MS	MONTBARD (FRANCE)	QSC-421 QSC-563	21.11.95 08.02.96				FERROUS & NONFERROUS BARS, SEAMLESS TUBULAR PRODUCTS AND STRUCTURAL SHAPES.
13	KRUPP - VDM GmbH (MANNESMANN GROUP)	MS MM	LANGENFELD (GERMANY)	QSC-553	31.08.96				MATERIAL MANUFACTURER OF FERROUS [illegible] NONFERROUS FIT TING WELDED WITH AND WHITOUTH FILLER METAL; SEAMLESS TUBULAR PRODUCTS
14	I.M.L. (INDUSTRIA MECC. LIGURE)	MM	RECCO (GENOVA)	EN 29002 (RINA)	OTT. 94				FITTINGS, BOLTS AND NUTS IN UNALLOYED, LOWALLOYED AND AUSTENITIC STEELQUALITIES. (FOR SBWR JOB / VN 0015)
15	F.B.M. - HUDSON	MM	TERNO D'ISOLA (BERGAMO)	S - U U2-PP EN 29001 (D.N.V.)	MAG. 97 SET. 96				ECHANGE TUBES (INCONEL) BENDING.

 Preparato da / Prepared by : AMMQ

ADS TEST PROGRAM AT V.A.P.O.R.E. FACILITY (ENEA-CASACCIA)



VAPORE AF2 by I.B.7DNU7QUA - 4/3/96

ANSALDO

Un'Azienda Finmeccanica

Progetto / project	Identificativo / document no.
SBWR	SBW5280IQQXQ001000

Cliente / client	Comm. / job. no	Emittente / issued by	Pagina / page	Di / of
ENEL	N27000	DNU/DIR	1	37

Rag. disc. / disc.code	Rif. str. prod. / prod. str. no	Identificativo componente / equipment identification code	Tipo doc. / doc type	Cl. ris. / class	Allegati / enclosures
		PCC & IC	PGQ		

Titolo / title

PIANO DELLA QUALITA' per la realizzazione delle unità prototipo di Isolation Condenser (IC) e Passive Containment Cooling Condenser (PCC) dell'Associazione Temporanea di Impresa tra Consorzio GENESI e ANSALDO GIE

Quality Assurance Plan for the realization of the Isolation Condenser (IC) and Passive Containment Cooling Condenser (PCC) prototype units of the temporary Enterprise Association between the GENESI Consortium and ANSALDO GIE

Derivato da / derived from

Sostituisce / substitutes

Rev 0 / rev. — Data / date 20.04.1993 — Descrizione / description — Stato valid. / rev.scope

Redazione / prepared by: A. ZANARDI

Controllo /Approvazione / checked by/approved by: A. PEDEMONTE

Autorizzazione emissione / issue authorization: R. ADINOLFI

Il presente documento è redatto in lingua Italiana ed in lingua Inglese; la versione inglese comincia a pag. 21.

This document is written both in English and Italian languages; the English translation beginning is at pag. 21.

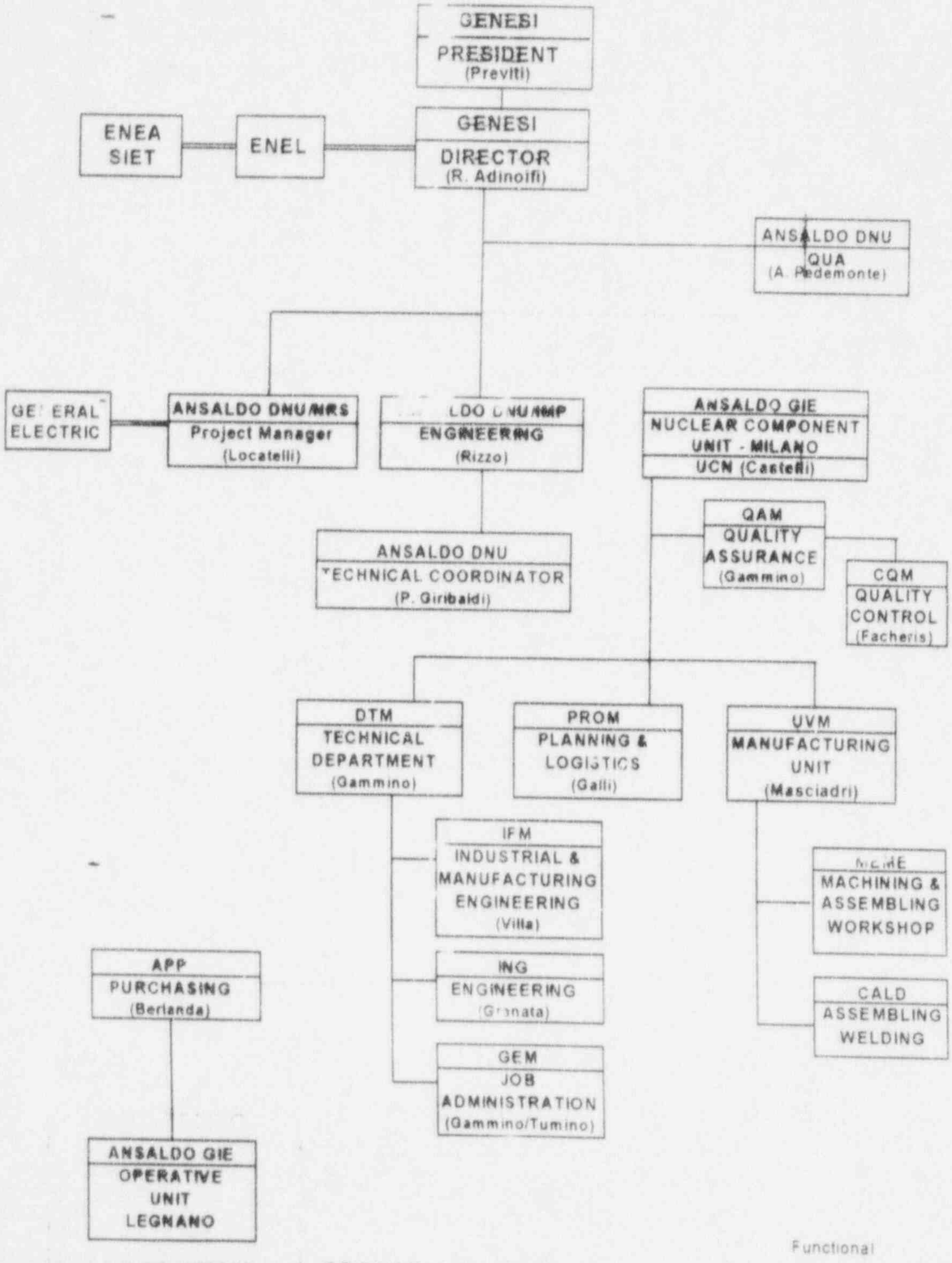
NAC-GTD

1505

1996

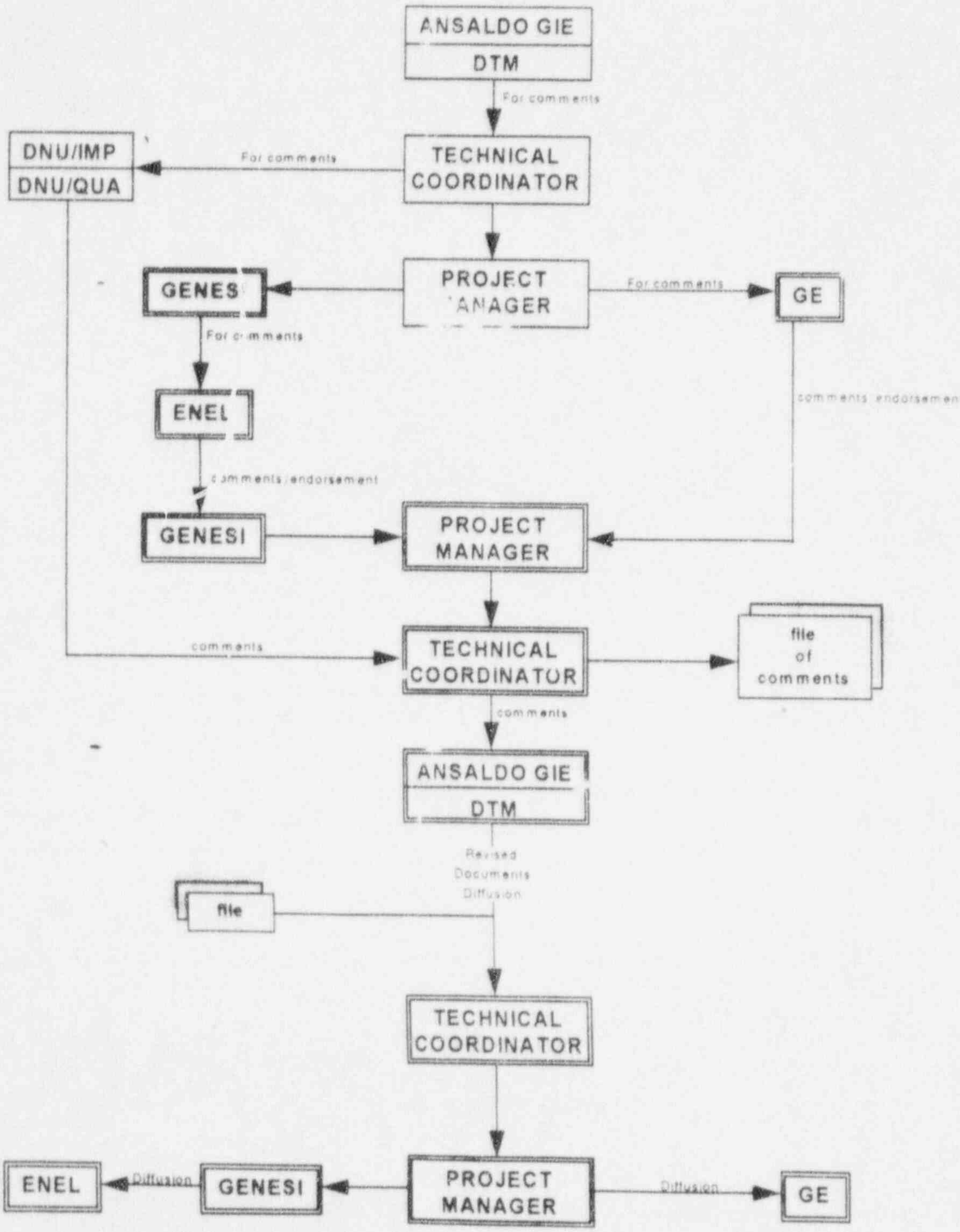
Rev. / rev.	Data / date	Descrizione / description	Stato valid. / rev. scope	Redazione / prepared by	Controllo/ approvazione / checked by/ approved by	Autorizzazione emissione / issue authorization
1	15.07.1993	Rev. seguito riunione ENEL 6/7-5-93 + rapp. NRS/NRG103 revised following meeting 6/7-5-93 + report NRS/NRG 103		ZANARDI	PEDEMONTE	ADINOLFI

INDEX



ORGANIZATION DIAGRAM OF
THE TEMPORARY ENTERPRISE
ASSOCIATION GENESI - ANSALDO GIE

FLOW CHART OF DOCUMENTS ISSUED BY ANSALDO GIE



The American Society of Mechanical Engineers

CERTIFICATE OF AUTHORIZATION

This certificate accredits the named company as authorized to use the indicated symbol of the American Society of Mechanical Engineers (ASME) for the scope of activity shown below in accordance with the applicable rules of the ASME Boiler and Pressure Vessel Code. The use of the code symbol and the authority granted by this Certificate of Authorization are subject to the provisions of the agreement set forth in the application. Any construction stamped with this symbol shall have been built strictly in accordance with the provisions of the ASME Boiler and Pressure Vessel Code.

COMPANY

ANSALDO ENERGIA SPA
STABILIMENTO DI MILANO
VIALE SARCA, 336
20126 MILANO, ITALY

SCOPE

CLASS 1, 2, 3 & CS SHOP ASSEMBLY OF STAMPED COMPONENTS, PARTS, APPURTENANCES, PIPING SUBASSEMBLIES & COMPONENT SUPPORTS AT THE ABOVE LOCATION ONLY

AUTHORIZED	APRIL 14, 1995 REVISED: AUGUST 17, 1995
EXPIRES	MARCH 5, 1998
CERTIFICATE NUMBER	N-2859
SYMBOL	NA

CHAIRMAN OF THE BOILER
AND PRESSURE VESSEL COMMITTEE

DIRECTOR, ACCREDITATION AND CERTIFICATION

CERTIFICATE OF AUTHORIZATION

The American Society of Mechanical Engineers

This certificate accredits the named company as authorized to use the indicated symbol of the American Society of Mechanical Engineers (ASME) for the scope of activity shown below in accordance with the applicable rules of the ASME Boiler and Pressure Vessel Code. The use of the code symbol and the authority granted by this Certificate of Authorization are subject to the provisions of the agreement set forth in the application. Any construction stamped with this symbol shall have been built strictly in accordance with the provisions of the ASME Boiler and Pressure Vessel Code.

COMPANY

ANSALDO ENERGIA SPA
STABILIMENTO DI MILANO
VIALE SARCA, 336
20126 MILANO, ITALY

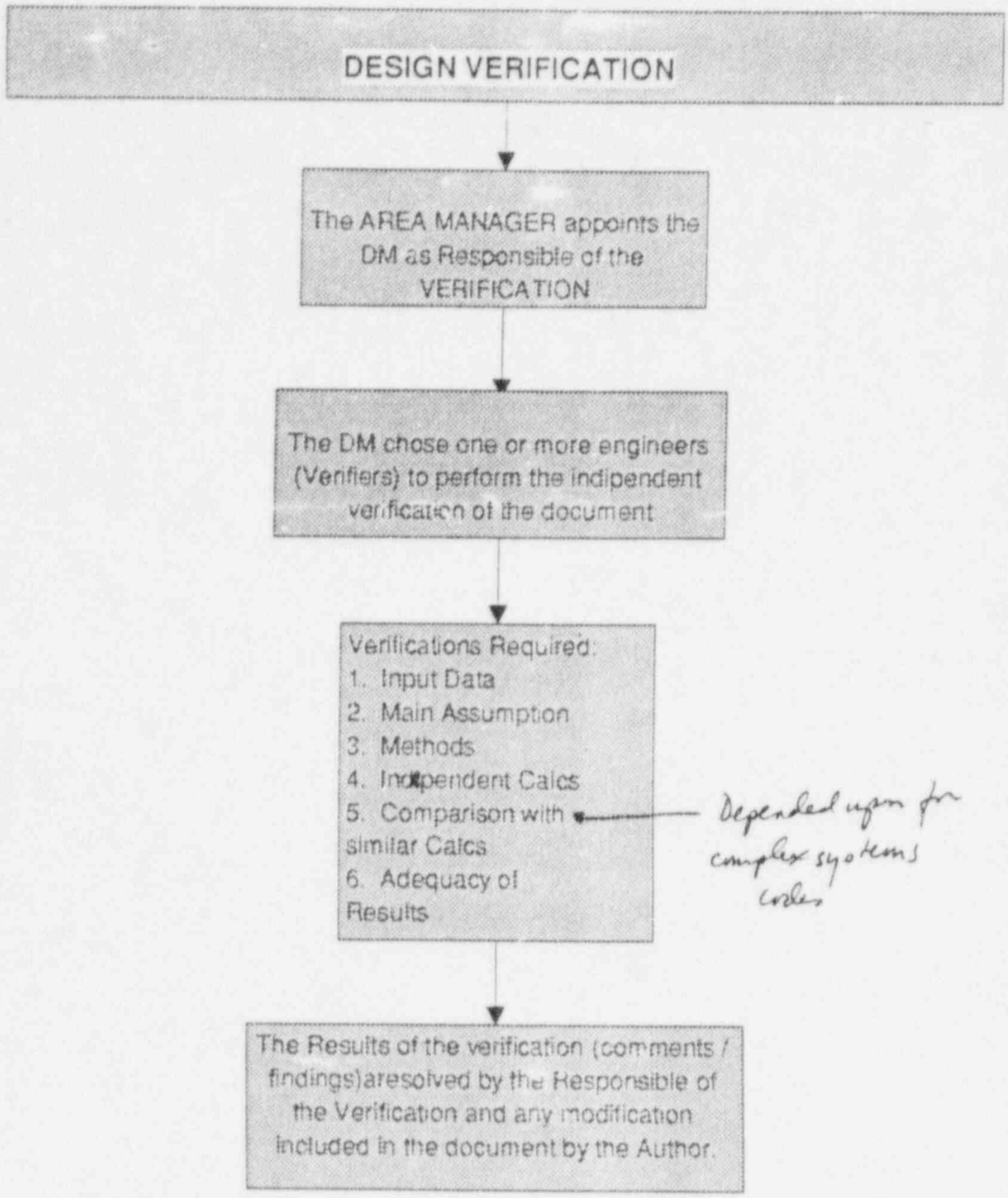
SCOPE

CLASS 1, 2, 3 & MC VESSEL PARTS & APPURTENANCES; CLASS 1, 2 & 3 PUMP PARTS & APPURTENANCES, COMPONENT SUPPORTS FABRICATION & COMPONENT SUPPORTS PARTS & PIPING SUBASSEMBLIES; CLASS 2 & 3 STORAGE TANK PARTS & APPURTENANCES; CLASS CS CORE SUPPORT STRUCTURE PARTS & APPURTENANCES AND CLASS 1 CONTROL ROD DRIVE HOUSINGS AT THE ABOVE LOCATION ONLY

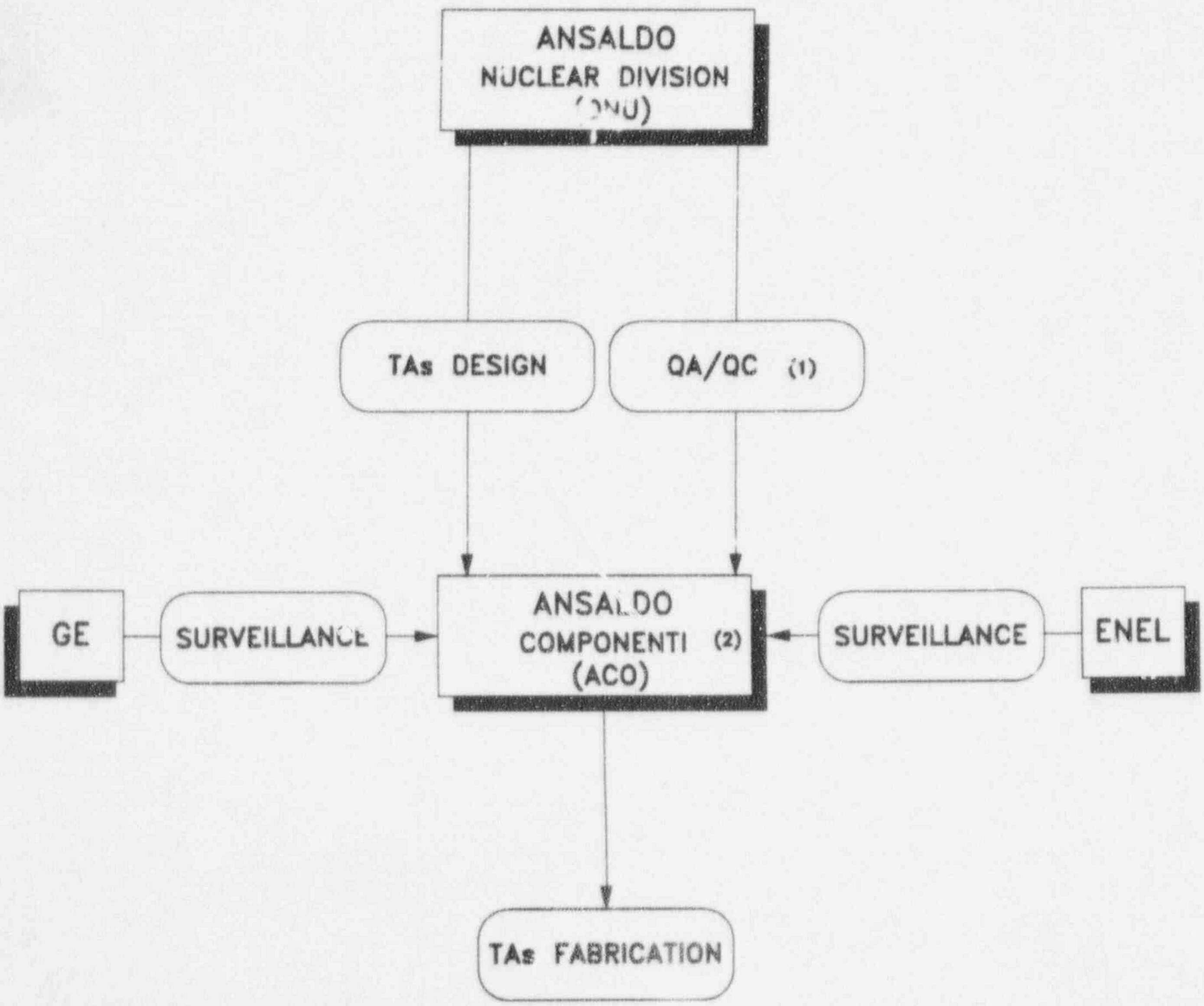
AUTHORIZED	APRIL 14, 1995 REVISED: AUGUST 17, 1995
EXPIRES	MARCH 5, 1998
CERTIFICATE NUMBER	N-2860
SYMBOL	NPT

CHAIRMAN OF THE BOILER
AND PRESSURE VESSEL COMMITTEE

DIRECTOR, ACCREDITATION AND CERTIFICATION


DESIGN VERIFICATION
The AREA MANAGER appoints the DM as Responsible of the VERIFICATION
The DM chose one or more engineers (Verifiers) to perform the indipendent verification of the document
Verifications Required:
1. Input Data
2. Main Assumption
3. Methods
4. Indipendent Calcs
5. Comparison with similar Calcs
6. Adequacy of Results
Depended upon for complex systems codes
The Results of the verification (comments / findings)aresolved by the Responsible of the Verification and any modification included in the document by the Author.

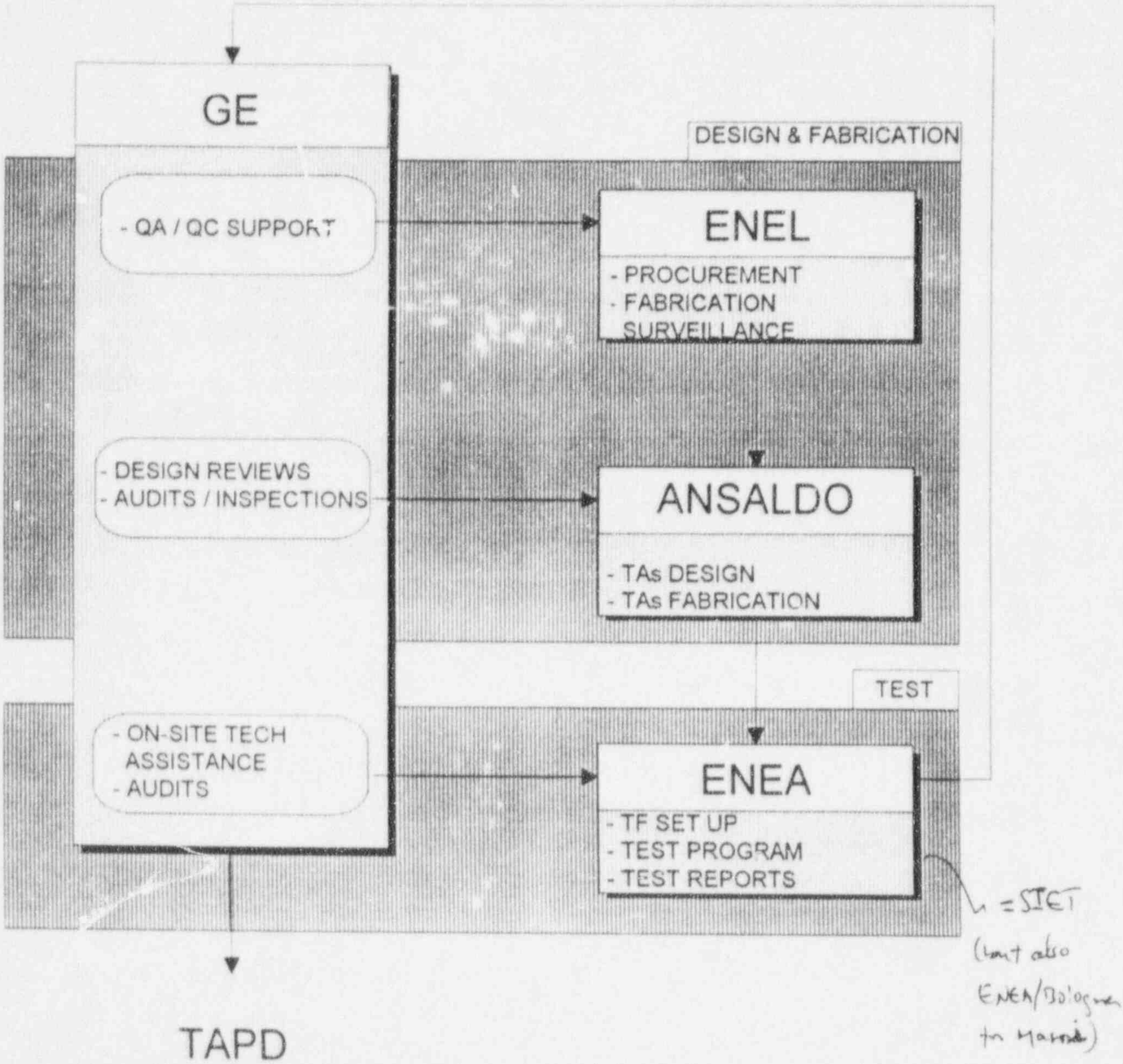
IC/PCC FABRICATION : QUALITY CONTROL



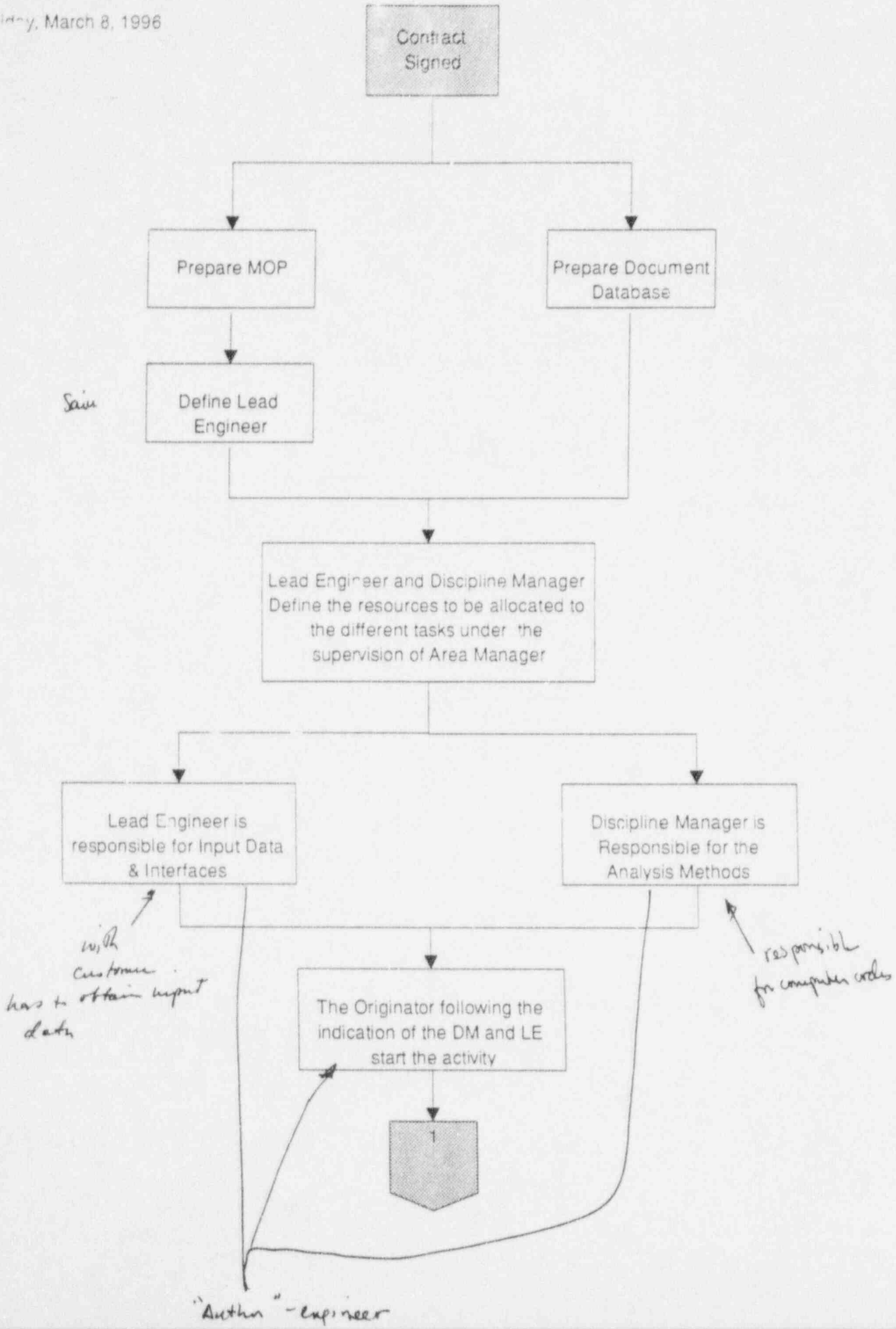
(1) COMPLYING WITH NQA-1/1a, 1983

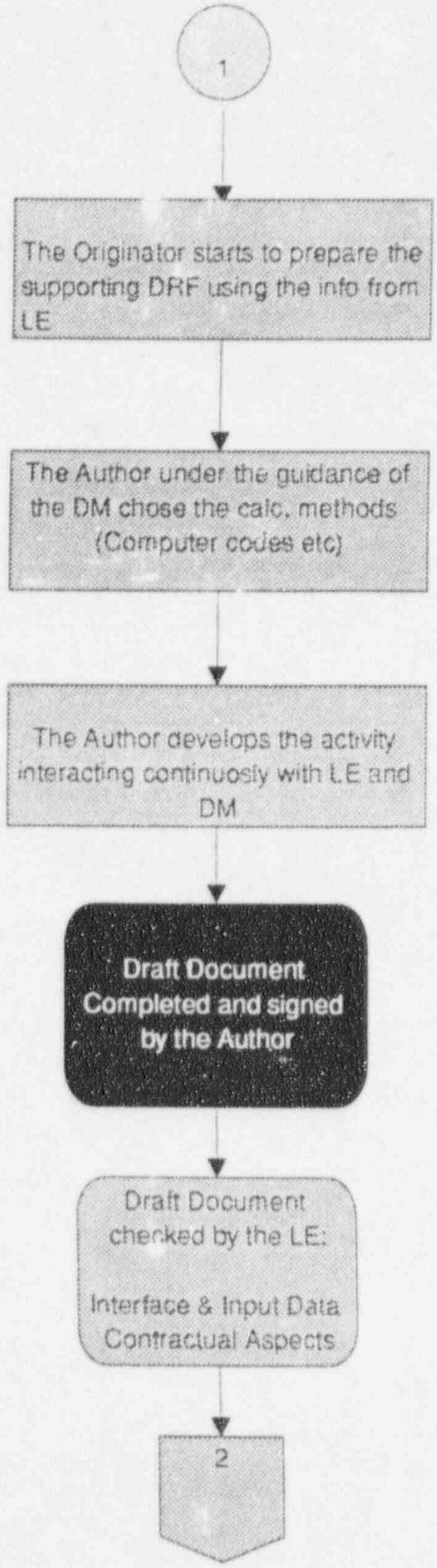
(2) N-STAMP HOLDER SINCE LATE SIXTIES

PANTHERS 4-PARTY AGREEMENT



Friday, March 8, 1996



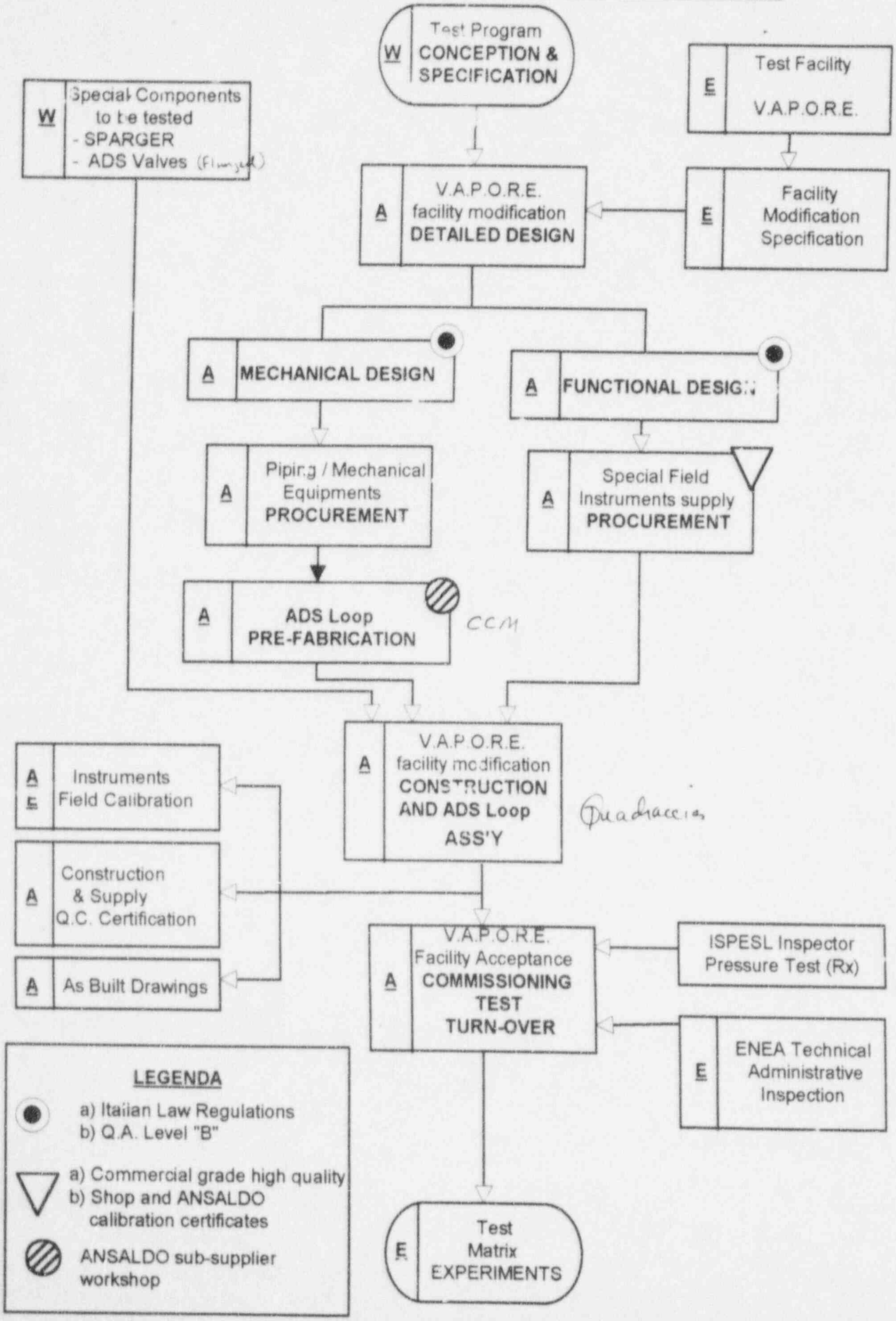

1
The Originator starts to prepare the supporting DRF using the info from LE
The Author under the guidance of the DM chose the calc. methods (Computer codes etc)
The Author develops the activity interacting continuosly with LE and DM
Draft Document Completed and signed by the Author
Draft Document checked by the LE:
Interface & Input Data
Contractual Aspects
2

V.A.P.O.R.E. Facility modifications

ACTIVITY ------------ CONTRACT	CONTRACT QUALITY REQUIREMENT	ACTUAL QUALITY SYSTEM
Phase "A" ENEA ---> Ansaldo	Best Engineering Practice	Ansaldo Q.A. Program (*) Technical Documentation
Phase "B-1" ENEA ---> Ansaldo	Best Engineering Practice (fulfills the requirements of Westinghouse Specification)	Ansaldo Q.A. Program (*) Technical Documentation
Phase "B-2" Westinghouse ---> Ansaldo	Westinghouse Specification Ref.: Contract Letter MB-21177-S	Ansaldo Q.A. Program (*) Technical Documentation

(*) According to DNU Quality Assurance Manual

ADS TEST PROGRAM AT V.A.P.O R.E. FACILITY (ENEA-CASACCIA)



The American Society of Mechanical Engineers

CERTIFICATE OF ACCREDITATION

This certificate accredits the named company as having had the adequacy of their quality assurance program verified for the scope of activity shown below in accordance with the applicable rules of the Boiler and Pressure Vessel Code of the American Society of Mechanical Engineers (ASME). This certificate does not include authorization to use a code symbol stamp. The accreditation granted by this certificate is subject to the provisions of the agreement set forth in the application.

COMPANY

ANSALDO ENERGIA SPA
STABILIMENTO DI MILANO
VIALE SARCA, 336
20126 MILANO, ITALY

SCOPE

NA, CLASS 1, 2, 3 & CS INSTALLATION OF COMPONENTS, PARTS, APPURTENANCES, PIPING SUBASSEMBLIES & COMPONENT SUPPORTS AT VARIOUS LOCATIONS, SUBJECT TO AUDIT

AUTHORIZED APRIL 14, 1995 REVISED: AUGUST 17, 1995

EXPIRES MARCH 5, 1998

CERTIFICATE NUMBER N-2861

Domenic A. Canonico

CHAIRMAN OF THE BOILER
AND PRESSURE VESSEL COMMITTEE

Alan Bagner

DIRECTOR, ACCREDITATION AND CERTIFICATION

The American Society of Mechanical Engineers

CERTIFICATE OF AUTHORIZATION

This certificate accredits the named company as authorized to use the indicated symbol of the American Society of Mechanical Engineers (ASME) for the scope of activity shown below in accordance with the applicable rules of the ASME Boiler and Pressure Vessel Code. The use of the code symbol and the authority granted by this Certificate of Authorization are subject to the provisions of the agreement set forth in the application. Any construction stamped with this symbol shall have been built strictly in accordance with the provisions of the ASME Boiler and Pressure Vessel Code.

COMPANY

ANSALDO ENERGIA SPA
STABILIMENTO DI MILANO
VIALE SARCA, 336
20126 MILANO, ITALY

SCOPE

CLASS 1, 2 & 3 VESSELS & PIPING SYSTEMS; CLASS 2 & 3 STORAGE TANKS; CLASS CS CORE SUPPORT STRUCTURES AND CLASS 1 CONTROL ROD DRIVE HOUSINGS AT THE ABOVE LOCATION ONLY

AUTHORIZED	APRIL 14, 1995 REVISED: AUGUST 17, 1995
EXPIRES	MARCH 5, 1998
CERTIFICATE NUMBER	N-2858
SYMBOL	N

Domenic A. Canonico

CHAIRMAN OF THE BOILER
AND PRESSURE VESSEL COMMITTEE

Alan Bagner

DIRECTOR, ACCREDITATION AND CERTIFICATION

®

ATTACHMENT 2

PERSONNEL CONTACTED AT MEETING SITES

Personnel Contacted at Paul Scherrer Institute

(Note: not all individuals attended all meetings.)

NRC Representatives:

R. McIntyre
J. Peralta
J. Monninger
A. Levin
J. Kudrick
D. Scaletti

GE Representatives:

J. Torbeck
G. Wingate
J. Fitch
J. Quinn

PSI Representatives:

J. Dreier
G. Varadi
J. Healzer
G. Yadigaroglu
T. Bandurski
M. Huggenberger
O. Fischer

Personnel Contacted at Ansaldo

(Note: not all individuals attended all meetings.)

NRC Representatives:

R. McIntyre
J. Peralta
A. Levin
D. Scaletti

GE Representatives:

P. Billig
N. Barclay
S. Kanobelj

Westinghouse Representative:

R. Tupper

Ansaldo Representatives:

E. Lutini
M. Marsano
A. Buscaglia
P. Baroni
A. Pedemonte
G. Omnis
G. Locatelli
G. Rizzo

Personnel Contacted at Dodewaard

GKN Representatives:

W. Nissen
Mr. Hoekstra
Mr. Karuza

KFD Representative:

G. Vayssier

TUD Representative:

T. van der Hagen

design certification as a focal point. However, it does seem clear that Ansaldo will continue to be involved with Westinghouse as part of the AP600 program, with possible future testing at VAPORE related to ADS valve qualification (outside of design certification, but related to FOAKE activities).

Concerning Dodewaard, since the plant will be undergoing modifications over the next year or so, related to the extension of its operating license, it is not clear how much testing will be conducted in the near term. However, in view of the existing database and the broad expertise in this area that exists at the plant and at TUD, it appears to be in the NRC's interest to maintain contact with GKN, TUD, KFD, and other related organizations, to stay cognizant on testing and analysis with regard to BWR stability and thermal-hydraulics.

Attachments:
As stated

DISTRIBUTION:
Central File
PDR
SRXB R/F
WRussell/FMiraglia
MCullingford
AThadani
GHolahan/MVirgilio
RJones
OGC
EJordan/AEOD
ACRS
KPerkins
GMcPherson
TCollins
ADrozd
JKudrick
JPeralta
JMonninger
DScaletti
AUlses
EKendrick
VMcCree
WUpshaw
PBoehnert
ALevin

96-10

SRXB:DSSA	SRXB:DSSA	SRXB:DSSA
ALEVIN	TCOLLINS	RJONES
4/3/96	4/3/96	4/3/96

DOCUMENT NAME: G:\EUROPE.M96

O+M-15-1
X-1A-1-4-1