No. 19252

UNITED STATES OF AMERICA
and
SWITZERLAND

Agreement on research participation and technical exchange in the United States Nuclear Regulatory Commission (USNRC) Loss of Fluid Test Program and the Emergency Core Cooling Systems-Reflood Program of the Swiss Federal Institute for reactor research (EIR) covering a four-year period (with appendices). Signed at Washington on 15 June 1979 and at Wurenlingen on 9 July 1979

Authentic text: English.

Registered by the United States of America on 7 November 1980.

AGREEMENT[1] ON RESEARCH PARTICIPATION AND TECHNICAL EXCHANGE BETWEEN THE UNITED STATES NUCLEAR REGULATORY COMMISSION (USNRC) AND THE SWISS FEDERAL OFFICE OF ENERGY (EAEW) FOR AND ON BEHALF OF THE GOVERNMENT OF SWITZERLAND IN THE USNRC LOSS OF FLUID TEST PROGRAM AND THE ECCS-REFLOOD PROGRAM OF THE SWISS FEDERAL INSTITUTE FOR REACTOR RESEARCH (EIR) COVERING A FOUR-YEAR PERIOD

The Contracting Parties,

Considering that the United States Nuclear Regulatory Commission (USNRC) and the Swiss Federal Office of Energy (EAEW)

(*a*) Have a mutual interest in cooperation in the field of reactor safety research, with the objective of improving and thus ensuring the safety of reactors on an international basis;

(*b*) Have as a mutual objective the achievement of full reciprocity in the exchange of technical information in the field of reactor safety research;

(*c*) Recognize that their respective countries are parties to the Implementing Agreement on the Technical Exchange of Information in the Field of Reactor Safety Research and Development of the International Energy Agency, signed on May 20, 1976, under which this Agreement is executed, and

(*d*) Have expressed their intention to participate cooperatively in the USNRC-funded Loss of Fluid Test (LOFT) research program at the Idaho National Engineering Laboratory, which is operated under contractual arrangement between the U.S. Department of Energy and EG&G, Inc., and in the ECCS-Reflood Program carried out by the Swiss Federal Institute for Reactor Research (EIR),

Have agreed as follows:

Article I. PROGRAM COOPERATION

The USNRC and the EAEW, in accordance with the provisions of this Agreement and subject to applicable laws and regulations in force in their respective countries, will join together for cooperative research in the USNRC LOFT program, as described in appendix 1, or as amended, and in the EAEW ECCS-Reflood research program, as described in appendix 2, or as amended.

Article II. SCOPE OF AGREEMENT

2.1. Both parties agree that the research programs which each has included for technical exchange under the terms of this Agreement and are described in appendices 1 and 2, are open for participation by the other party.

2.2. Subject to the availability of funds, each party agrees to provide the necessary personnel, materials, equipment and services for the performance of their respective programs, as described in appendix 1 or 2, or as amended.

[1] Came into force on 9 July 1979 by signature, in accordance with section 6.1.

2.3. Each party agrees to permit the other to assign up to two mutually agreed upon technical experts to participate in the program that the permitting part is sponsoring, as described in appendix 1 or 2, or as amended.

2.4. Further, each party agrees to permit the other to assign a technical expert to participate in any program review group that the permitting party may have established for periodic reviews of the status and future plans of the program it is sponsoring. If one of the parties has not established a program review group, it will permit the other party to periodically review and consult with it in regard to program planning, testing and data analysis.

2.5. Each party agrees to provide to the other party access to all experimental data and results of analyses it has obtained or derived from the USNRC and EIR programs included under this Agreement, as well as access to operational computer codes and data it has developed or used to analyze the results of these two programs, except for proprietary codes and data, which will not be made available unless authorized by the owner.

2.6. Each party agrees to bear the total costs of transportation, living expenses and any other costs arising from its participation under this Agreement, and for the transport and related costs for apparatus and other equipment furnished by it.

Article III. PATENTS

3.1. With respect to any invention or discovery made or conceived during the period of, or in the course of or under, this Agreement for Swiss participation in the USNRC LOFT Program described in Appendix 1, or as amended, the USNRC as the recipient party and the EAEW as the assigning party, and for USNRC participation in the EIR ECCS-Reflood Program described in Appendix 2, or as amended, the EAEW as the recipient party and the USNRC as the assigning party, hereby agree that:

3.1.1. If made or conceived by personnel of one party (the assigning party) or its contractors while assigned to the other party (recipient party) or its contractors:

(*a*) The recipient party shall acquire all right, title, and interest in and to any such invention, discovery, patent application or patent in its own country and in third countries, subject to a nonexclusive, irrevocable, royalty-free license to the assigning party, with the right to grant sublicenses, under any such invention, discovery, patent application or patent for use in the production or utilization of special nuclear material or atomic energy; and

(*b*) The assigning party shall acquire all right, title, and interest in and to any such invention, discovery, patent application, or patent in its own country, subject to a nonexclusive, irrevocable, royalty-free license to the recipient party, with the right to grant sublicenses, under any such invention, discovery, patent application or patent, for use in the production or utilization of special nuclear material or atomic energy.

3.1.2. If made or conceived other than by personnel in paragraph 3.1.1 above and while in attendance at meetings or when employing information which has been communicated under this Agreement by one party or its contractors to the other party or its contractors, the party making the invention shall acquire all right, title, and interest in and to any such invention, discovery, patent application or patent in all countries, subject to the grant to the other party of a royalty-free, nonexclusive, irrevocable license, with the right to grant sublicenses, in and to any such invention, discovery, patent application, or patent in all countries, for use in the production or utilization of special nuclear material or atomic energy.

3.2. Neither party shall discriminate against citizens of the country of the other party with respect to granting any license or sublicense under any invention pursuant to subparagraphs 3.1.1 and 3.1.2 above.

3.3. Each party will assume the responsibility to pay awards or compensation required to be paid to its nationals according to the laws of its country.

Article IV. EXCHANGE OF SCIENTIFIC INFORMATION AND USE OF RESULTS OF PROGRAM

4.1. Subject to the other provisions of this article, the parties agree that information developed or transmitted under this Agreement may be given wide distribution. Except as may be noted hereinafter, such knowledge and information may be made available to the public through customary channels and in accordance with normal procedures of the parties.

4.2. It is recognized by both parties that in the process of exchanging information, or in the process of other cooperation, the parties may provide to each other "industrial property of a proprietary nature." Such property, including trade secrets, inventions, patent information, and know-how made available hereunder and which bears an appropriate restrictive legend clearly indicating that the property is of proprietary commercial value, shall be respected by the receiving party and shall not be used for commercial purposes or made public without the prior consent of the transmitting party. Such property is defined as that which:

(*a*) Has been held in confidence by its owner; and

(*b*) Is of a type which is customarily held in confidence by its owner; and

(*c*) Has not been transmitted by the transmitting party to other entities (including the receiving party) except on the basis that it be held in confidence; and

(*d*) Is not otherwise available to the receiving party from another source without restriction on its further dissemination.

4.3. Recognizing that "industrial property of a proprietary nature," as defined above, may be necessary for the conduct of specific programs included under this Agreement, or may be included in an exchange of information, such property shall be used only in the furtherance of nuclear safety programs in the receiving country. Its dissemination will, unless otherwise mutually agreed to in writing, be limited as follows:

(*a*) To persons within or employed by the receiving party, and to other concerned government agencies of the receiving party, and

(*b*) To prime or subcontractors of the receiving party for use only within the country of the receiving party and within the framework of its contract(s) with the respective party engaged in work relating to the subject matter or the information so disseminated, and

(*c*) On an as-needed, case-by-case basis, to organizations licensed by the receiving party to construct or operate nuclear production or utilization facilities, provided that such information is used only within the terms of the license and in work relating to the subject matter of the information so disseminated, and

(*d*) To contractors of licensed organizations in subparagraph (*c*) receiving such information, for use only in work within the scope of the license,

provided that the information disseminated to any person under subparagraphs (*b*), (*c*) and (*d*) above shall be pursuant to an agreement of confidentiality.

4.4. The application or use of any information exchanged or transferred between the parties under this Agreement shall be the responsibility of the party receiving the information, and the transmitting party does not warrant the suitability of the information for any particular use or application.

Article V. DISPUTES

5.1. Any dispute between the parties concerning the interpretation or application of this Agreement which is not settled by negotiation or other agreed mode of settlement shall be referred to a tribunal of three arbitrators to be chosen by the parties, and who shall also choose the chairman of tribunal. Should the parties fail to agree upon the composition of the tribunal or the selection of the chairman, the President of the International Court of Justice shall, at the request of the parties, exercise those responsibilities. The tribunal shall decide any such dispute by reference to the terms of this Agreement and any applicable laws and regulations, and its decision on all questions of facts shall be final and binding on the parties.

Article VI. FINAL PROVISIONS

6.1. This Agreement shall enter into force upon signature of the parties and shall remain in force for a period of 4 years.

6.2. Either party may withdraw from the present Agreement after providing the other party written notice 6 months prior to its intended date of withdrawal.

6.3. If either of the research programs described in Appendices 1 and 2 is substantially reduced or eliminated, other research work of equivalent programmatic interest may be substituted upon mutual agreement of the parties.

6.4. Either party may at its option participate in a continuation of the other party's program beyond the 4-year period of this Agreement under mutually acceptable terms and conditions.

For the United States Nuclear Regulatory Commission:

By: [*Signed — Signé*][1]
Title: Executive Director for Operations
Date: June 15, 1979

For the Swiss Federal Office of Energy:

By: [*Signed — Signé*][2]
Title: Deputy Director
Date: July 9, 1979

APPENDIX 1

USNRC LOSS OF FLUID TEST PROGRAM

1. *Objectives*

The experimental objectives of the LOFT test program are:

a. Provide the experimental data required to evaluate analytical methods and codes used to predict: (*a*) what happens in large PWRs when a LOCA occurs; (*b*) the manner in which current engineered safety features of commercial nuclear plants, such as emergency core cooling systems (ECCS), perform when activated and how effective they are during a LOCA; and (*c*) the margins of safety provided by the current designs of engineered safety features for PWRs in the event of a LOCA.

b. Identify and investigate any unexpected events or thresholds which may occur during the performance of LOFT tests.

2. *Facility descriptions*

The major component of LOFT is the Mobile Test Assembly (MTA), which consists of a 55-thermal-megawatt reactor system and reactor cooling system mounted on a double-width rail-transportable test dolly. The MTA is installed in a high-pressure containment building that has auxiliary systems for reactor plant support and a contiguous underground control room. In the event

[1] Signed by Lee V. Gossick — Signé par Lee V. Gossick.
[2] Signed by C. Zangger — Signé par C. Zangger.

of major unexpected problems or at the completion of a series of tests, the MTA can be moved by rail from the containment building into a nearby large "hot shop" for remote disassembly or maintenance.

The reactor core is 5-1/2 feet long, 2 feet in diameter, and contains 1300 PWR type fuel rods. The core is instrumented with high-temperature thermocouples and other specially developed instrumentation to measure temperatures, flow, pressures and coolant levels inside the reactor vessel. The highly instrumented fuel for LOFT was designed and fabricated by the Exxon Nuclear Company at Richland, Washington.

The reactor coolant system has one active, heat-dissipating, operating loop—that models the three unbroken loops of a four-loop plant—and a special blowdown loop that can simulate a ruptured loop in a large PWR. The blowdown loop contains special quick-opening valves that simulate rupture of a large reactor coolant pipe in a commercial nuclear steam suppression tank which is pressure and temperature controlled to simulate the containment pressure conditions calculated to exist following a large PWR loss-of-coolant accident.

The LOFT facility's ECCS has the same components as that of a large PWR and is designed to provide a simulated performance. Three systems for emergency coolant injection are provided: (1) gas-pressurized water-filled accumulators that can inject a large volume of water into the reactor system quickly; (2) high-pressure injection pumps that can provide a small flow of high-pressure coolant for small breaks; and (3) low-pressure injection pumps that can provide large volumes of water for core cooling after an experiment or for core cooling in the highly unlikely event of a major primary system rupture. The primary coolant system and ECCS are extensively instrumented and ECCS injection points and flow rates are easily varied for experimental purposes.

3. *Integral Test Program*

The test program began with nonnuclear loss-of-coolant tests (see table 1) and will continue with nuclear experiments including degraded performance of the ECC system such as pump failures and loss of offsite power—those situations which must be considered when making licensing calculations. Nonnuclear tests are defined as those in which no nuclear core heat is produced, while nuclear experiments are those in which the reactor is producing nuclear heat and therefore a coolant temperature differential exists across the core. The LOFT nuclear experiment plan consists of multiple test series with full, intermediate and small-sized breaks, alternate ECC injection, anticipated transients and steam generator tube rupture.

To provide experimental data for analysis evaluation, nonnuclear and nuclear experiments will be conducted to investigate items such as the following:

(1) Break flow coefficients and break geometry as they affect depressurization.

(2) Pump resistance effects, at powered, coast-down, and locked rotor conditions.

(3) Downcomer bypass and mixing of the emergency coolant with the reactor coolant.

(4) Structural response of the core and system components during blowdown.

(5) Heat transfer of the steam generator as it affects depressurization and reflood rate.

(6) Three-dimensional hydraulic effects in the core, plenums, and other volumes of the reactor coolant system.

(7) Two-phase resistance of various system components.

(8) Containment (back) pressure as it affects the ECC flooding rate.

(9) ECC flow patterns, interaction with counter-current steam flow, and steam generation from wall heat transfer in the reactor upper annulus and downcomer.

(10) The effects of scaling various reactor coolant system components.

(11) Reproducibility of experimental results.

(12) Influence of the fuel pellet and fuel element gas pressure on the magniture of the sensible heat.

(13) Fuel cladding growth or ballooning during the LOCA.

(14) Heat transfer behavior from the core to the coolant during the LOCA.

Other major areas of investigation in the LOFT integral test program will include: unexpected LOCA phenomena, unexpected event identification, threshold identification, and synergistic effect identification.

4. *Current Status (May 1978)*

The LOFT facility is currently undergoing systems and components acceptance testing prior to initiation of the nuclear experimental program. Five nonnuclear blowdown tests have been completed. The nuclear core has been installed and initial criticality achieved on February 5, 1978. Low power physics testing and the final nonnuclear blowdown test have been completed. The nuclear power range test program is scheduled to be completed by early 1979 prior to beginning the nuclear blowdown experiment program (see tables II and III).

Table I. LOFT NONNUCLEAR EXPERIMENTAL SERIES L-1

Experiment	*Break Size*	*Break Type*	*ECC Injection*	*System Pressure (MPa)*
L1-1	1/2	Hot leg	Cold leg	9.3
L1-2	Full	Cold leg	Cold leg (delayed)	15.5
L1-3	Full	Cold leg	Lower plenum	15.5
L1-4	Full	Cold leg	Cold leg	15.5
L1-5*	Full	Cold leg	Cold leg	15.5

*With nuclear core

Table II. L2 SERIES—POWER ASCENSION SERIES

Test No.	*Power Level (w/cm^2)*	*PCS Flow/ΔT (kg/s)/(°C)*	*Pre-Pressurized*	*Primary coolant pumps*	*ECC Delay*
L2-2	78	171.4/23.9	No	On	No
L2-3*	117	171.4/35.8	No	On	No
L2-4	156	228.1/35.8	No	On	No
L2-5	117	171.4/35.8	No	Off/locked	Yes
L2-6	117	171.4/35.8	Yes	On	No

All 200% DECL breaks

All assume loss of one LPIS and HPIS train

* Additional lower power test may be inserted here if decontamination preparations not complete.

Table III. LOFT NUCLEAR EXPERIMENTAL PROGRAM

Test Sequence	*Number of Experiments*	*Schedule*
Power Ascension (full size break)	6	11/78-12/80
Intermediate and Small Cold Leg Breaks	3	5/81-3/82
Alternate ECCS	3	8/82-6/83
Hot Leg Breaks	2	11/83-4/84
ATWS	2	9/84-2/85
Steam Generator Tube Rupture	2	7/85-12/85
Dismantle		1986

APPENDIX 2

EIR PROGRAMS ON ECC THERMAL-HYDRAULICS AND LOCA ANALYSIS

1. *Experiments on ECC Thermal-Hydraulics at EIR*

1.1. *Reflood and Spray Cooling Experimental Program*

The objective of these experiments is to investigate the thermal-hydraulic and heat-transfer behavior during reflooding, spraying and coupled reflooding and spraying in PWR and BWR-bundle geometry. The results of the experiments are expected to give information on transient heat transfer coefficient and quenching times as a function of the initial cladding temperature, pressure, power and injection flow rates.

The experimental program will be performed in four stages:

—Annular geometry (reflood)

—Monotube geometry (reflood)

—Rod bundle geometry (reflood experiment with LOFT geometry and conditions).

—Rod bundle geometry (reflood and spray cooling experiment with BWR geometry and conditions).

The first step is the investigation of the flow pattern during reflooding in a special single rod test-section with a quartz-glass outer tube wall, allowing visual observations. The testing of the instrumented electrically heated fuel rod simulators for bundle experiments will also be carried out in this configuration.

To investigate the influences of the particular parameters on heat-transfer and rewetting, preliminary tests will be carried out in a vertical internally cooled tube (Monotube) which simulates a full length subchannel in a reactor fuel bundle.

The PWR reflood experiment in bundle geometry (NEPTUN) has been designed to provide reflood data applicable to the analysis of LOFT nuclear tests. This experiment plays an analogous role for LOFT as FLECHT does for the commercial PWR. It will allow to investigate individual effects and to carry out parameter studies in a 37-rod bundle test.

At a later stage, experiments are planned for a BWR-type bundle during the reflood and spray-cooling phase.

1.2. *Experimental Facility NEPTUN*

The test facility NEPTUN designed for reflood experiments is currently under construction. Its scheme is shown in fig. 1.

The loop has the ability to carry out experiments in bundle or single-tube test sections. The system is designed for controlled inlet water temperature, inlet flow rate and back pressure in the upper plenum. The measurements include:

—Fluid temperatures,

—Heater element surface temperatures,

—Void fraction with DP-cells along the length of the test section,

—Carry-over rate, and

—Steam mass flow rate.

The main characteristics of the test facility NEPTUN are given in table 1. The cross-section of the bundle simulating a part of the LOFT fuel element is shown in figure 2. The heater elements required for NEPTUN are developed and manufactured at EIR. The specifications of the electrically heated rods having a chopped cosine axial power distribution can be seen in figs. 3A and 3B.

1.3. *Two-Phase Flow Research Work*

The research and development work, which is based on earlier studies in this field at EIR, includes the investigation of particular two-phase flow phenomena as well as the development of new measurement techniques for transient and steady-state two-phase flows. The programs consist of:

a. Fluid-to-fluid modelling. Investigations have been carried out on scaling void-fraction, pressure drop and critical heat flux for water and Freon 113 in steady-state flow conditions. This program has been completed.

b. Development of measurement methods to determine cross section-averaged gas (steam) and liquid velocities. The methods under development are based on laser-correlation for gas and on a luminescent technique for the liquid phase. The aim of these investigations is to achieve more accurate information about two-phase flow rate in steady state and if possible under transient conditions.

c. Development and improvement of an impedance void meter to determine void fraction in transient two-phase flow.

The facilities for these experiments are a Freon loop and an air-water loop. The laser instrumentation for the measurement of the phase velocities is developed and the first tests have been carried out under steady-state flow conditions in the air-water loop. The next step of this program will include investigations in steam-liquid conditions and adaption of these techniques for transient conditions.

The new measuring techniques currently under development will be used in the experimental program as soon as they are fully developed and sufficiently tested. The EIR reflood experiments using simulated LOFT heater rods will be equipped with conventional instruments so that their success does not depend on the stage of the development of the new techniques.

2. *The LOCA Analysis Program*

The primary aim of this program is to investigate the thermal-hydraulics during a LOCA with ECC. The main objectives are:

—To gain insight in merits of the LOCA analysis codes currently used for licensing;

—To critically review the models used in LOCA computer codes;

—To compare the main codes with well-defined experimental results (e.g., CSNI-standard problems) to demonstrate their abilities to predict real situations;

—To provide a theoretical back-up to the EIR transient experiments, especially of the LOFT related tests described above in section 1;

—To perform detailed studies on the existing ECC safety philosophies and systems of PWRs and BWRs, and perform consulting work for the licensing of Swiss LWRs with respect to ECCS.

The following computer codes for LOCA analysis are available at EIR: (1) RELAP 4/MOD 3 (best estimate and evaluation model options for hydraulic analysis during blowdown phase); (2) RELAP 4-FLOOD (hydraulic analysis during the reflooding phase); (3) RELAP 4/MOD 5; (4) THETA 1-B and TOODEE-2 (thermal analysis of PWR fuel elements during LOCA transients); and (5) MOXY-EM (for single elements) and COBRA-III (for bundles): (thermal analysis of BWR fuel elements during LOCA transients).

Table 1. NEPTUN FACILITY CHARACTERISTICS

Max. bundle-power	100 k W
Max. coolant flow	1 kg/sec
Flooding rate	2 to 15 cm/sec
Flooding water temp	20° to 147°C
System pressure	1 to 5 bar
Initial cladding temperature	Up to 900°C
Geometry of test sections	
Monotube	D_h = 14.4 mm
	L = 3760 mm
37 rod bundle	P/D = 1.33
	D = 10.72 mm
	L = 1680 mm

FIG. 1

NEPTUN

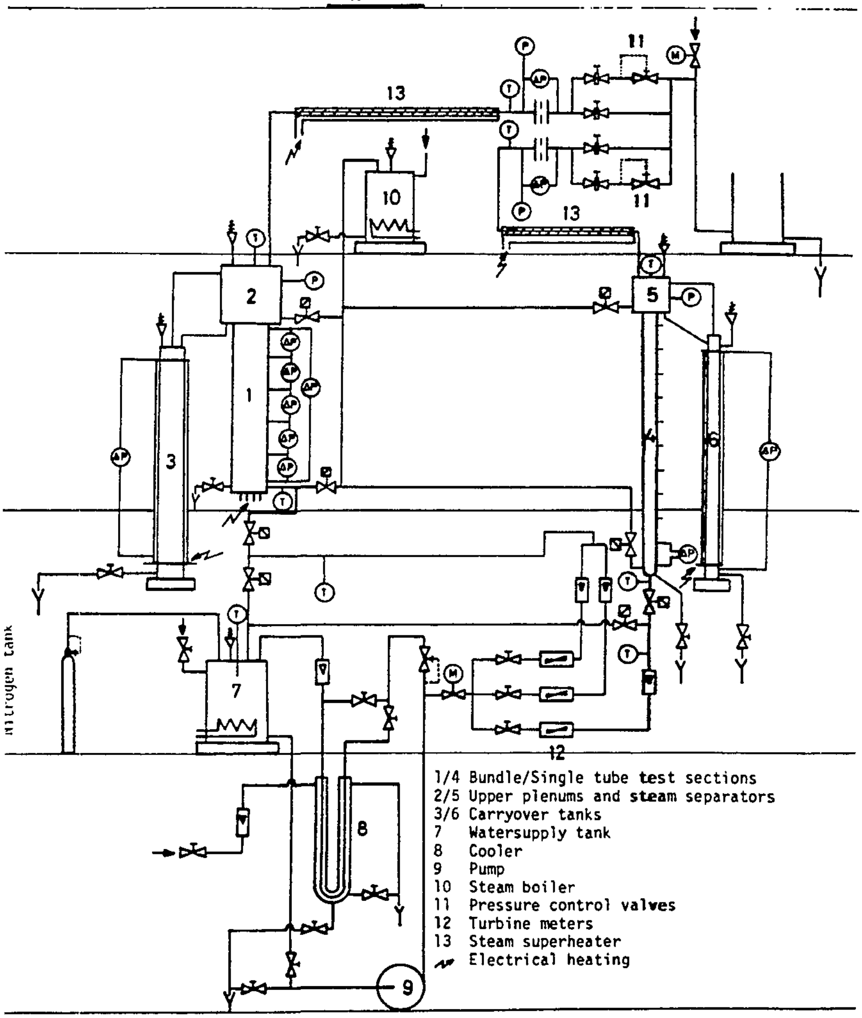
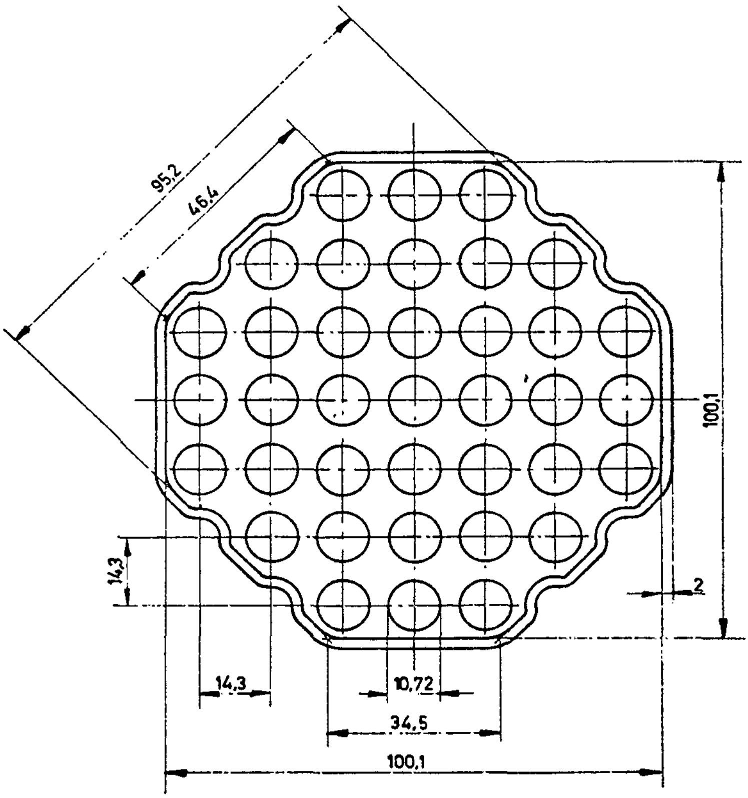

1/4 Bundle/Single tube test sections
2/5 Upper plenums and steam separators
3/6 Carryover tanks
7 Watersupply tank
8 Cooler
9 Pump
10 Steam boiler
11 Pressure control valves
12 Turbine meters
13 Steam superheater
Electrical heating

FIG. 2

NEPTUN BUNDLE



37 - Rod Configuration

FIG. 3 A

HEATER SPECIFICATIONS

- HEATED LENGTH	1680	MM
- O. DIAMETER	10.72	MM
- POWER DISTRIBUTION	CHOPPED COSINE	
- ROD POWER	2.3	KW
- AVERAGE HEAT FLUX	4.15	W/CM^2
- PEAK HEAT FLUX	6.35	W/CM^2
- PEAK LINEAR HEAT RATING	21.4	W/CM
- AXIAL PEAKING FACTOR	1.53	

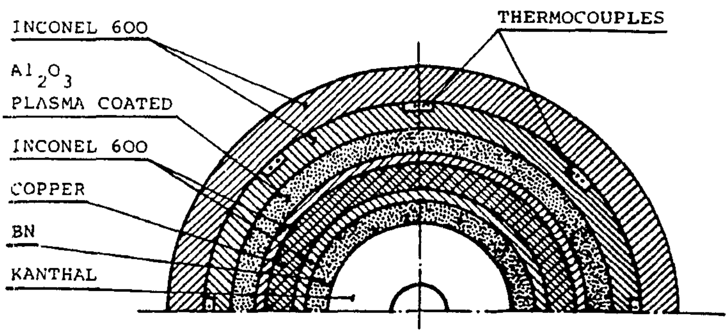


FIG. 3 B

HEATER AND THERMOCOUPLE ASSEMBLY