THE SCANDINAVIAN PCRV MODEL PROJECT : STRESS CALCULATION AND EXPERIMENTAL VERIFICATION

S.I. ANDERSEN,

Danish Atomic Energy Commission, Denmark

E. HAMRE,

Norges Tekniske Høgskole, Trondheim, Norway

T. TARANDI,

VBB Vattenbyggnadsbyran, Stockholm, Sweden

ABSTRACT

The paper describes part of a joint development programme by Denmark, Finland, Norway and Sweden in the field of prestressed concrete vessels for water reactors. PCRV's for water reactors are characterized by their relatively high ratio of wall thickness to radius and, in the Scandinavian design, by a removable top closure that permits refuelling to be done in the traditional LWR manner.

The present paper presents the results of the theoretical and experimental structural analysis obtained during testing of the Scandinavian PCRV model vessel at Atomenergi, Sweden.

Testing of the model vessel showed good agreement with theoretical predictions.

1. INTRODUCTION

Some years ago a joint study of prestressed concrete reactor vessels was started in the Scandinavian countries incl. Finland. As the conditions (pressure, insulation etc.) greatly differ from those for gas-cooled reactors, it was evident already at an early stage that it was necessary to verify the analytical calculations by experimental investigations. In the case of light water reactors it was also necessary to provide the vessel with a removable lid. It was therefore decided to build a model vessel to a scale of 1:3.5 of a prototype vessel for a BWR of about 800 MWe.

In the following a description of the analytical and experimental stress analysis of the Scandinavian model vessel at AB Atomenergi, Studsvik, Sweden, is presented. A more general description of the development programme is given in [8].

2. DESCRIPTION OF THE PCRV MODEL VESSEL

The principal arrangement of the Scandinavian PCRV model vessel is shown in fig. 1.

The vessel has an internal diameter of 2 m and height of 4 m. Design pressure is 85 bars, which corresponds to a wall thickness of 1.1 m. The thickness of the bottom and the lid is 1.2 m.

The bottom slab is perforated by penetrations for control rods, circulation pumps, steam outlets etc. The BBRV system is used to prestress the vessel. The vertical cables are units of 50 tons (15 x 6 mm) and the horizontal cables are of 170 tons (55 x 6 mm).

The nominal prestress level is about 1.5 and 1.75 times the internal pressure load in the horizontal and axial directions respectively. In addition, there is reinforcing steel corresponding to about 0.6 and 0.8 times the internal pressure load in the hoop and axial direction respectively (with yield stress in the steel).

The model vessel has a removable lid. The forces due to internal pressure from the lid to the vessel walls are transferred through a great number of struts (40 in this case). Every strut is supplied with a wedge to minimize the influence of tolerances, The loads from the struts are distributed to the concrete by two steel flanges, one of which is anchored in the lid and the other in the upper part of the vessel wall. This later flange functions at the same time as the anchorage of the vertical cables at the upper end of the vessel. At the lower end the cables are anchored in a continuous horizontal plate ring.

The vessel is sealed by a toroidal ring which is bolted to the lid and the vessel wall respectively, with O-rings between the toroid flanges and the flanges of the lid and the vessel.

The concrete in the model vessel has a min. 28-day cylinder strength of 430 kp/cm^2.

The internal surface of the vessel is provided with a liner of compound plate (7 mm carbon steel + 3 mm stainless steel) anchored in concrete with studs with 18 cm square pitch.

On the concrete side of the liner there are cooling pipes. A French manufactured thermal insulation (type CAFL) is used. The insulation is mounted on a removable casing. The bottom insulation is applied directly to the liner.

The design temperature of the concrete at the internal surface is 70°C in the case of water-filled insulation and 50°C if the insulation is gas-filled.

The test facility includes systems for pressurizing the vessel with cold and hot water (300°C) or saturated steam. There are also systems for the regulating of the water level, gas supply to the insulation etc.

3. THEORETICAL STRESS ANALYSIS

The main part of stress analysis preceding the construction of the model vessel has been performed with a computer programme [1] based on the principle of dynamic relaxation [2]. The programme allows for different elastic moduli in all three coordinate directions in every computing element. It is also possible to take into account the influence of creep assuming a simple loading history.

Calculations have also been performed by the finite element method [3], [4]. It has therefore been possible to compare these different methods.

In all three programmes rotational symmetry has been assumed. The smallest outside diameter of the real vessel is taken as the outside diameter in the calculations.

The assumption of rotational symmetry is quite realistic as far as internal pressure loading is considered [5]. The horizontal prestressing system does not possess rotational symmetry, and fig. 2 shows different strain fields in 0° and 45° position in the vessel wall. The results shown are obtained by photoelastic measurements on a horizontal section through the vessel and measurements on the vessel [5]. As is seen from fig. 2, the calculations give reasonably good mean values of the prestressing strains.

In the three calculations, different degrees of idealization and fineness of mesh has been used, fig. 3. However, the stresses and strains calculated with coarser meshes in [1] and [4] yield results which comply very well with measurements and the more detailed calculations in [3]. This holds even in regions with complex shapes, as is seen in fig. 29.

Calculations have been made for various normal loading combinations of prestress, design pressure and temperature both in short- and long-time loading. As such calculations now are quite conventional only the results of creep calculations will be briefly reported here. As seen in fig. 4, the influence of creep is quite secondary during the life of the reactor.

A step-by-step overload calculation was made (see fig. 5) for the propagation of cracks in concrete and (fig. 6) for successively increasing deformations on the vessel.

Calculation of pressure behind the liner with a programme for temperature calculation [6] has been made for a circumferential slit in the liner (see fig. 7). For steel components as steel flanges, struts etc. special calculations have been performed. A programme for thin axisymmetric shells [7] has been used for the design of the sealing torus.

4. TESTING OF THE MODEL VESSEL

The model vessel was built in Studsvik, Sweden, during 1969.

A number of tests with internal pressure up to design pressure, 85 bars, as well as overload tests to 128 bars have been performed.

The loading history during the testing period is seen in fig. 8.

The instrumentation consists of the following instruments:

250	vibrating wire instruments
500	strain gauges
8	load transducers on reinforcing steel
240	thermo-couples
24	dynamometers for cable forces
31	deformation gauges (vibrating wire)
6	Glötzl stress instruments
24	crack detectors

The primary measurement values (frequency, change of resistance etc.) are punched on three different tapes, one for vibrating wire instruments, one for strain gauges and one for thermo-couples.

These primary values are transformed to strain, temperature, deformation etc. with a special computer programme and stored on a magnetic tape. Strains due to a specific loading are calculated with another computer programme.

Strains, stresses and deformations due to different loading conditions are presented in the following chapter.

5. TEST RESULTS AND COMPARISON WITH CALCULATIONS

As the distance between the vibrating wire instruments for the different directions was too high (about 100 mm) it was considered not to be meaningful to compute corresponding stresses. The test results are therefore presented in the following as strains and deformations, except for Glötzl-instruments.

5.1. Internal pressure loading

A typical strain-loading curve is shown in fig. 9. The curve is not exactly linear when loading. This is probably due to the properties both of strain measuring instruments and of concrete.

In fig. 10 strains in the equatorial plane due to 85 bars are shown and compared with computed values. Fig. 11 presents strains near the upper end of the vessel and fig. 12 shows strains in the vessel wall at the level of the inside of the bottom slab. As is seen from these figures, the agreement between computed and measured values is acceptable.

Fig. 13 shows the variation in tangential strain along a circumference and for various loads. The variations round the circumference are small, which is in accordance with photo-elastic investigations in Denmark (see fig. 2).

Fig. 14 shows the variation in tangential strain along a radius for various loads.

Fig. 15 shows the variation in tangential strain along a vertical line for various loads.

Fig. 16 shows the variation in the strain ε_{45^o} about 8 cm below the level of the inside of the bottom slab. The figure shows that no tensile strains occurs at pressures below 128 bars.

Fig. 17 shows the variation in tangential strain, and fig. 18 shows the variation in vertical strain for various loads in bottom penetration No. 10. Both curves show the relatively small values of the stresses in the directions under consideration (max. value ca 300 kp/cm^2).

Agreement between computed and measured values is very good in the lid (fig. 19) as should be expected due to the fact that the calculating model almost exactly corresponds to the geometry of the lid.

Fig. 20 shows stresses in the equatorial plane, measured with Glötzl-meters, as compared with calculated stresses.

The measuring of strains with instruments embedded in concrete is influenced by local inhomogenities such as cable holes, reinforcing steel and even aggregate dimensions. In this case the instruments - with 80 mm measuring length - were applied directly in the concrete - with max. aggregate dimension about 16 mm - without precasting in a finer aggregate dimension. Such influences are minimized when measuring deformations at the outer surfaces, as is seen in fig. 21.

The increase of cable forces due to internal pressure of 85 bars is about 1 % and is in agreement with calculations.

5.2. Hot test

A hot test of 4 weeks duration was carried out. Temperature distribution during start-up is shown in fig. 22. Steady-state temperature distribution was arrived at in about 5 days. Differences between calculated and computed values are mainly due to the fact that the calculation premises did not exactly correspond to the real circumstances.

Fig. 23 shows strain in the vessel wall during the test and the period immediately following. Some points of calculation are shown too. Good agreement is documented by the strains in the lid, fig. 24, because the calculating model almost perfectly corresponds to the real configuration. Fig. 25 shows the deformations on the outer surface. Deformation is maximum at about 1 week after start and begins to diminish after this time, which is also in agreement with calculations.

5.3. Long-time characteristics

Fig. 26 shows the variation of strains during about one year of different tests. The total change of strain in the hoop direction at equatorial plane is about 30 % of initial strain at the time of prestressing. This is considerably less than would be expected in conventional creep considerations. The calculations, made with tri-axial creep taken into account, show quite low creep strains anyway. Also the lid, fig. 27, shows the same low creep tendency.

Long-time variation of cable forces is shown in fig. 28.

5.4. Stresses in steel components of the vessel

The measured strains in the rotational symmetrical parts of the flanges are in close agreement with the calculated results. The total strains are compressive even at the overload tests as predicted by the calculations.

However, the stiffening ribs just above the lid locking struts are not readily accessible for theoretical stress analysis, one of the ribs was therefore heavily instrumented. Fig. 29 shows the direction of the principal stresses and the corresponding stress intensity, calculated in accordance with the v.Mieses yield theory. The principal stresses are compressive in a direction approximately parallel to the free edge of the rib. The maximum tensile stress measured was 5 kp/mm^2 at the design pressure.

The forces in the lid locking struts are shown in fig. 30. The integrated total force corresponds very well to the calculated load on the lid due to the internal pressure. The variation in force between the struts are due to friction, fabrication tolerances and some variation in preload of the single struts. The mean value for the normal stress in a strut at the design pressure was $\sigma_n = 12\ kp/mm^2$.

The toroidal seal between the lid and the vessel wall is loaded by internal pressure and radial and axial deformations due to the relative movements between the lid and the vessel wall. The calculated stresses in the seal are compared with the measured results in fig. 31. There is good agreement even in regions with steep gradients. The maximum stress intensity based on the measurements at the overload tests are $\sigma = 49\ kp/mm^2$; the yield strength of the seal material is greater than 60 kp/mm^2.

5.5. Special tests

Some tests have been performed in connection with the safety analysis of the vessel. One of these was the simulation of cable failure by unstressing a tendon. The variations of strains in concrete were small.

The failure of one lid locking strut was simulated, and the increase of the forces in the remaining struts are shown in fig. 32. The maximum increase corresponds to 25 % of the load under normal operating conditions.

Some tests with fast water filling of the insulation gap were carried out. The liner experienced a maximum temperature of about 125°C, which corresponds to a stress change of about -34 kp/mm^2 in the liner.

During a blow-down test, the maximum rate of depressurization was from 70 bars, 285°C, to 20 bars in 95 sec. There was no significant temperature change in the concrete and liner during this transient stress. Strain changes observed correspond to the pressure reduction.

Tests with pressure behind liner

In prestressed concrete vessels for water reactors the question of pressure permeations into concrete through an eventual crack in the liner is more important than in vessels for gas-cooled reactors due to the greater relative wall thickness of water reactor vessels. This difference is lessened to a certain extent by the introduction of the "pod boiler" design for gas-cooled reactors.

To investigate the pressure build-up behind the liner and to demonstrate the feasibility of a venting system for release of the pressure behind the liner an improvised experiment was made in the Scandinavian pressure vessel model in Studsvik.

The arrangement of the experiment is seen on fig. 33. The pressurizing medium is nitrogen. The pressure is supplied through a pipe with its open end 2 mm from the liner, thus simulating a leak with an area of about 0.8 cm^2. A perforated pressure relief pipe is located at a distance of about 200 mm from the mouth of the first pipe, i.e. from the leakage simulation point. The outer end of the pressure relief pipe is provided with a valve which is kept closed in order to measure the rate of pressure increase in the perforated pipe.

The tests were performed at several internal pressures. The results are seen in fig. 34. It is seen that in the beginning of the tests the increase of the pressure is relatively fast. A practically steady-state pressure is arrived at in about 10 min. after the beginning of each test. This time seems at first sight to be considerably less than what would be assumed on the basis of theoretical considerations.

The main conclusion of the test is that it is possible to detect even quite small leaks at an early stage. With a system of pipes it should be possible to localize such a leak. The pipes may be supplied with valves which open at a certain pressure level to release the pressure.

Even when pressurizing through the perforated pipe (with the leak area of about 15 cm^2) the same tendency was observed although the pressure in concrete was higher. When opening the valves to the atmosphere a quick decrease of pressure in concrete was observed.

6. CONCLUSIONS

One of the main purposes of the test - the feasibility of the removable lid - seems to have been successfully demonstrated by the model vessel test, both under normal operating conditions and during severe accident simulations.

The methods of analysis have been verified as the agreement between predicted and calculated values is good even in such cases as the bottom plate. The simple approach to creep calculations seems to give acceptable results. On the whole, the influence of creep is relatively moderate in this case with high tri-axial stress condition.

7. ACKNOWLEDGEMENTS

The authors are very indebted to all collaborators who enthusiastically have contributed to the successful performance of the Scandinavian model work, the results of which are presented in this report.

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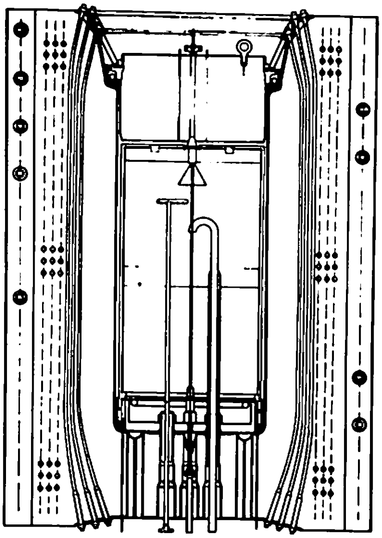


FIG.1 PCRV MODEL VESSEL

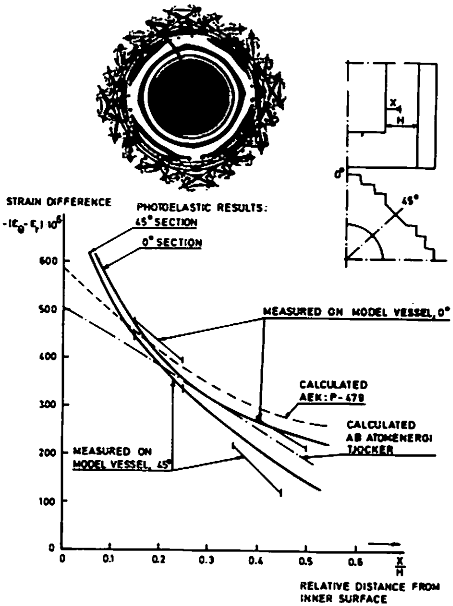
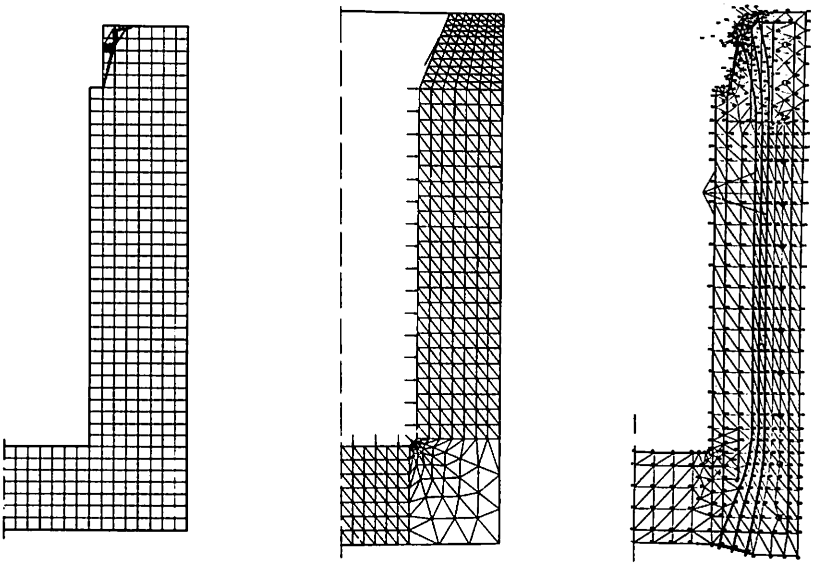


FIG. 2 PHOTOELASTIC INVESTIGATION



a) DYNAMIC RELAXATION
AB ATOMENERGI, SWEDEN

b) FINITE-ELEMENT-METHOD
DANISH AEC

c) FINITE-ELEMENT-METHOD
PROF. ZIENKIEWICZ

FIG. 3 COMPUTING MODELS

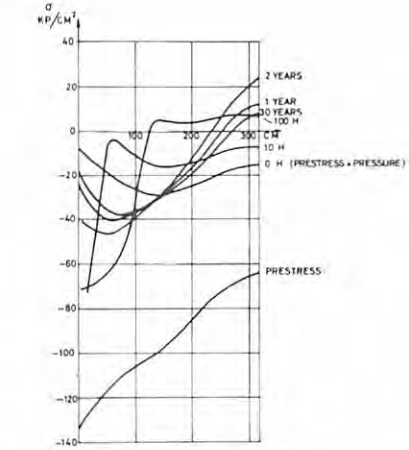


FIG 4 HOOP STRESSES AT EQUATORIAL PLANE AT DIFFERENT TIMES

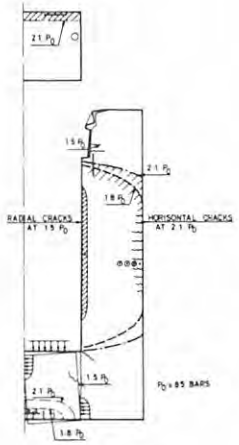


FIG. 5 SCHEMATICAL CRACKNING

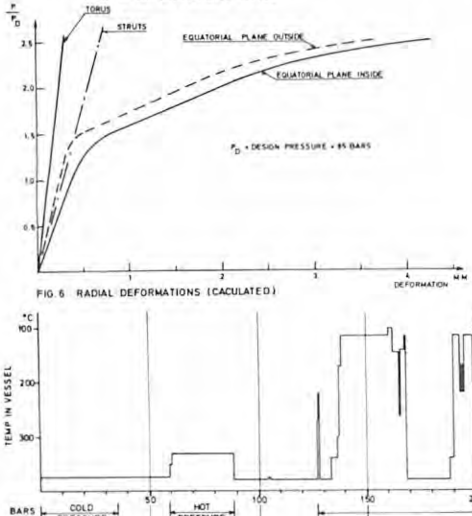


FIG. 6 RADIAL DEFORMATIONS (CACULATED)

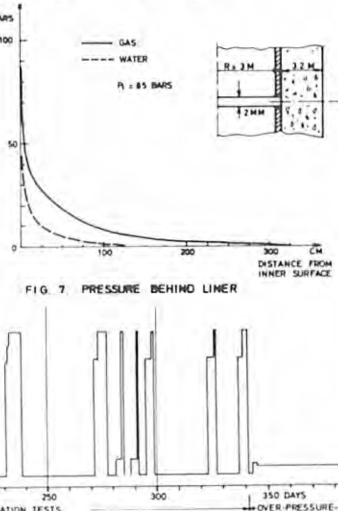


FIG. 7 PRESSURE BEHIND LINER

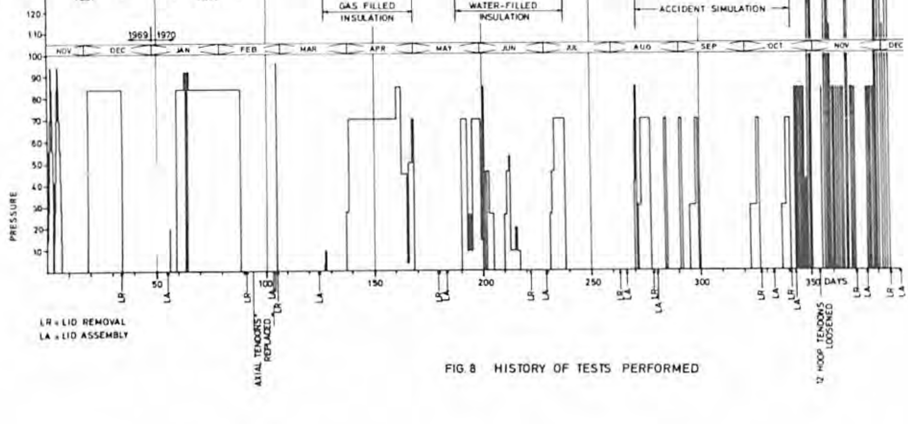
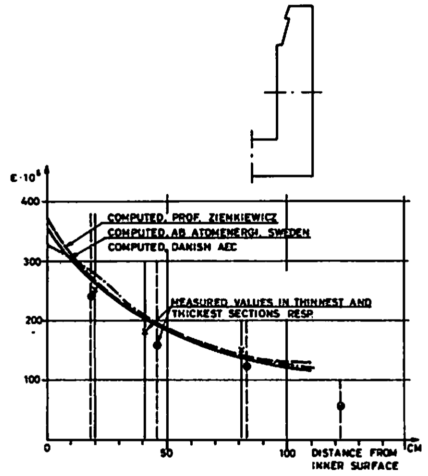
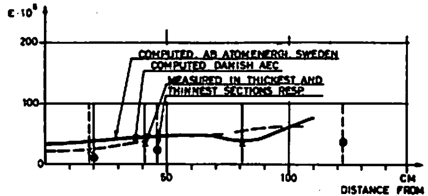


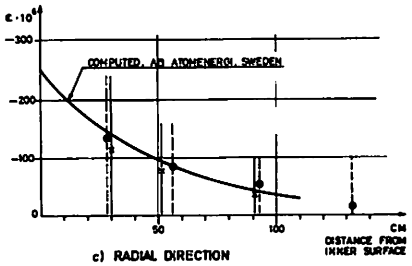
FIG. 8 HISTORY OF TESTS PERFORMED



a) HOOP DIRECTIONS



b) AXIAL DIRECTION



c) RADIAL DIRECTION

FIG. 10 STRAINS AT EQUATORIAL
PLANE FOR P=85 BARS

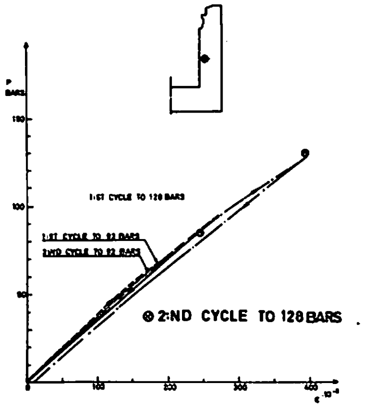
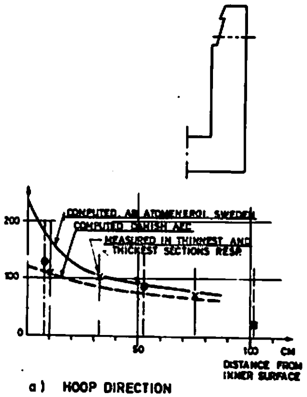
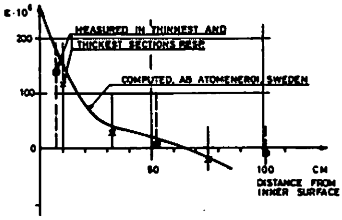


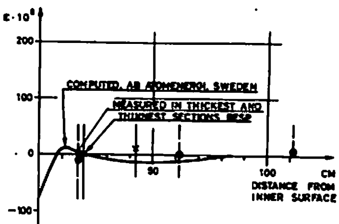
FIG. 8 HOOP STRAIN AS FUNCTION OF PRESSURE
AT EQUATORIAL PLANE



a) HOOP DIRECTION

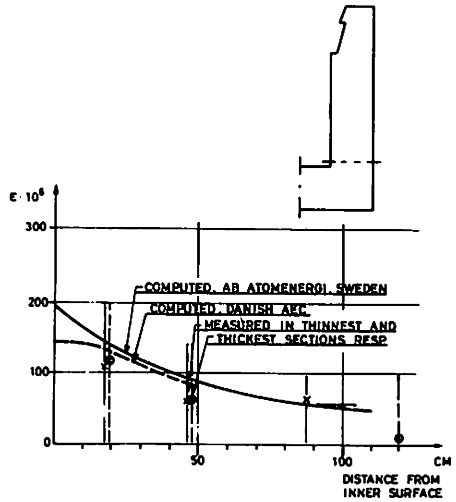


b) AXIAL DIRECTION

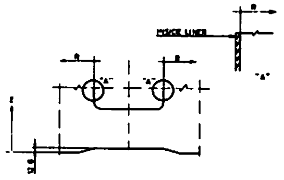


c) RADIAL DIRECTION

FIG. 11 STRAINS 500 MM BELOW THE UPPER
END OF THE VESSEL FOR P=85 BARS.



a) HOOP DIRECTION



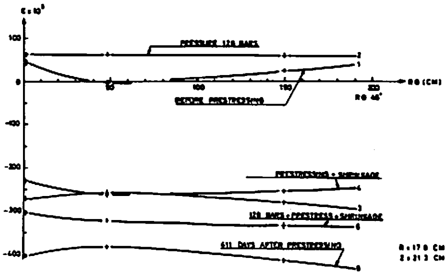
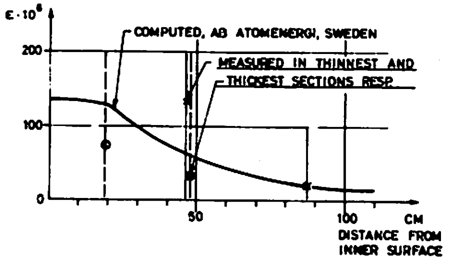


FIG 13 STRAINS IN HOOP DIRECTION



b) AXIAL DIRECTION

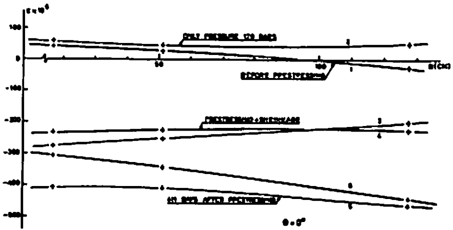
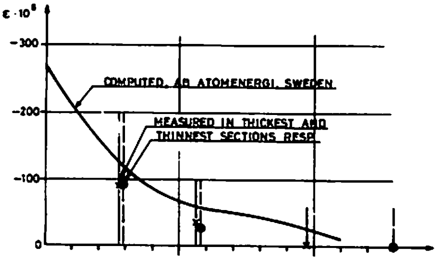


FIG. 14 STRAINS IN HOOP DIRECTION



c) RADIAL DIRECTION

FIG. 12 STRAINS IN A PLANE 200 MM ABOVE UPPER SURFACE OF THE BOTTOM SLAB FOR P= 85 BARS.

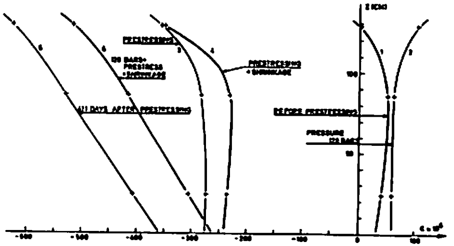


FIG. 15 STRAINS IN HOOP DIRECTION ALONG A VERTICAL LINE

θ = 0°
R = 17.9 CM

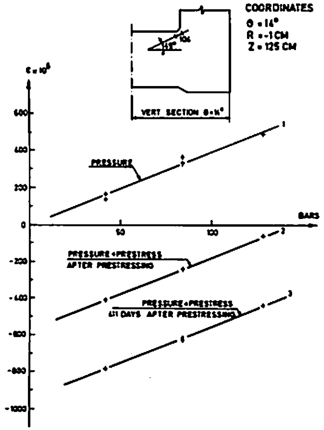
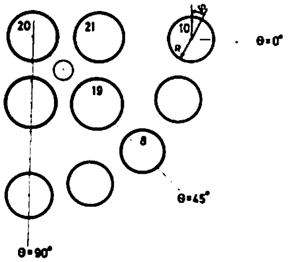


FIG. 16 STRAINS IN 45°- DIRECTION



BOTTOM PENETRATIONS

Tube no. 10
z = 28 cm

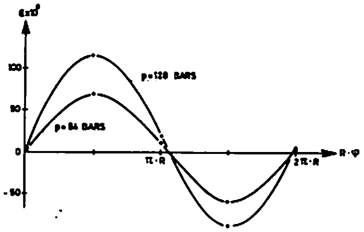


FIG. 17 STRAINS IN HOOP DIRECTION IN A BOTTOM PENETRATION

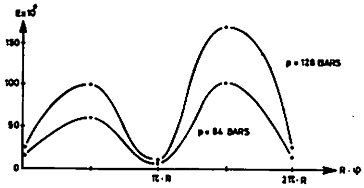


FIG. 18 STRAINS IN VERTICAL DIRECTION IN A BOTTOM PENETRATION

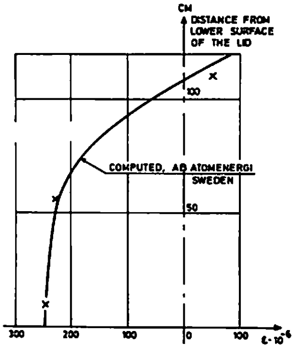


FIG. 19 RADIAL STRAINS AT THE CENTRE OF THE LID FOR P = 85 BARS

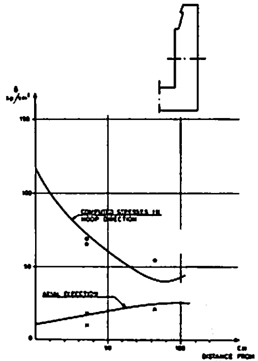


FIG. 20 STRESSES MEASURED WITH GLÖTZL - INSTRUMENTS

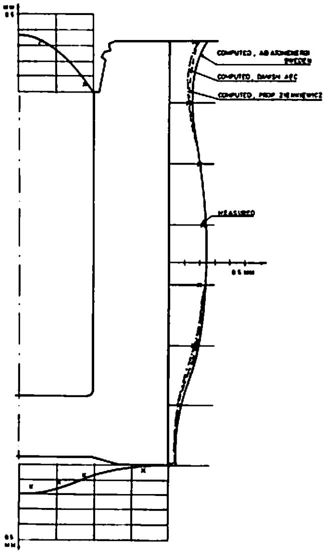


FIG 21 DEFORMATIONS ON EXTERNAL SURFACES

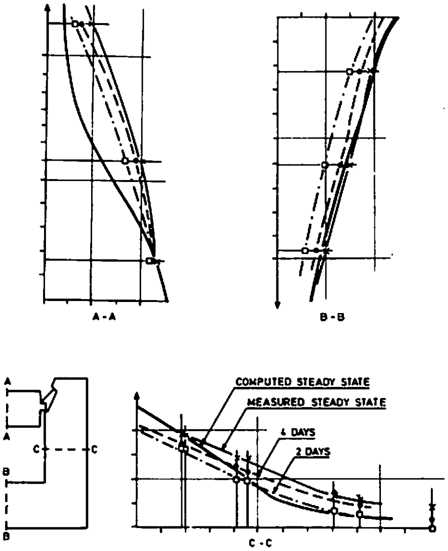


FIG. 22 TEMPERATURE DISTRIBUTION DURING HOT TEST

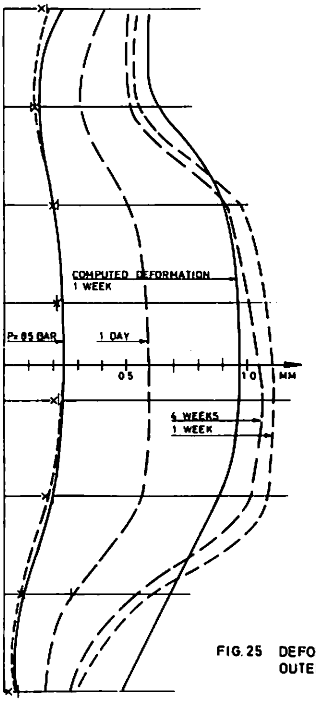


FIG. 25 DEFORMATION AT OUTER SURFACE

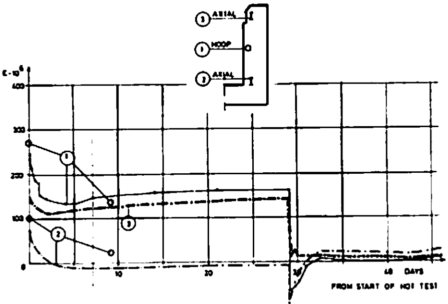


FIG 23 MEASURED STRAINS DURING HOT TEST

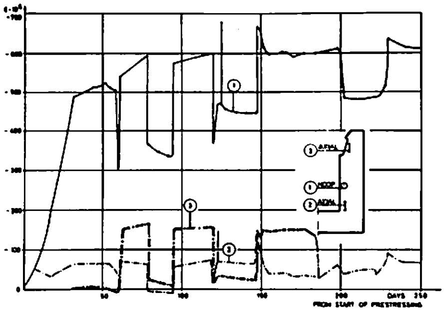


FIG. 26 MEASURED STRAINS IN THE VESSEL

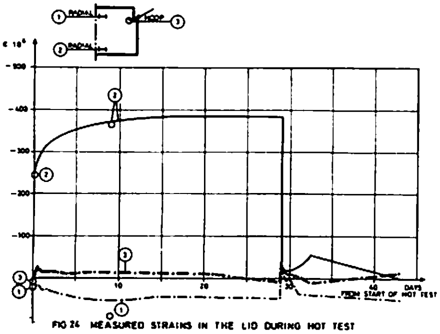


FIG 24 MEASURED STRAINS IN THE LID DURING HOT TEST

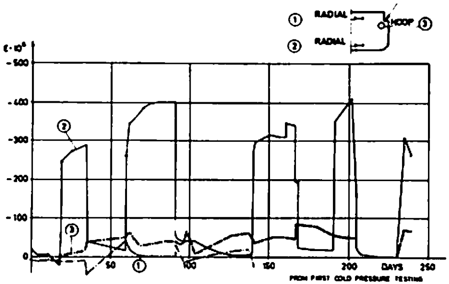


FIG.27 MEASURED STRAINS IN THE LID

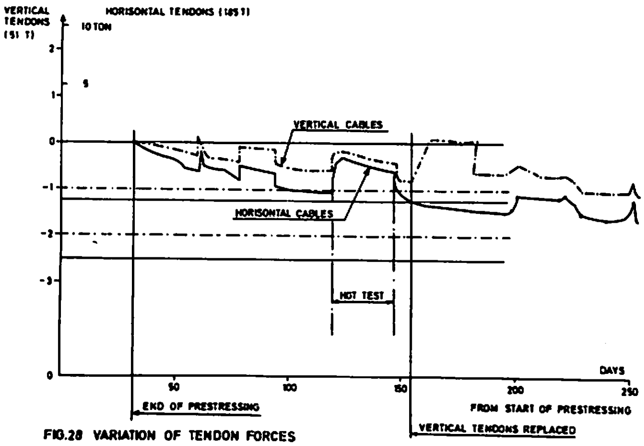


FIG.28 VARIATION OF TENDON FORCES

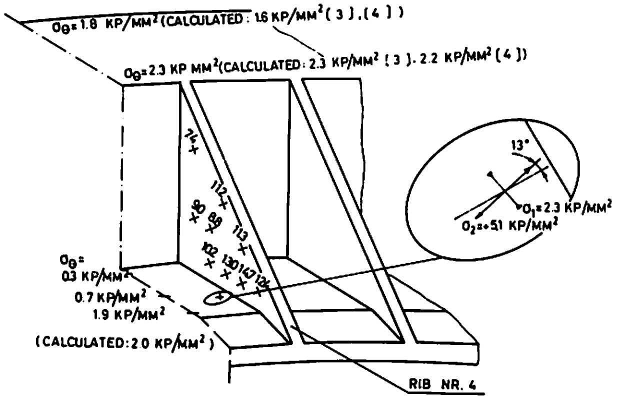


FIG. 29 PRINCIPAL STRESSES IN STIFFENING RIBS

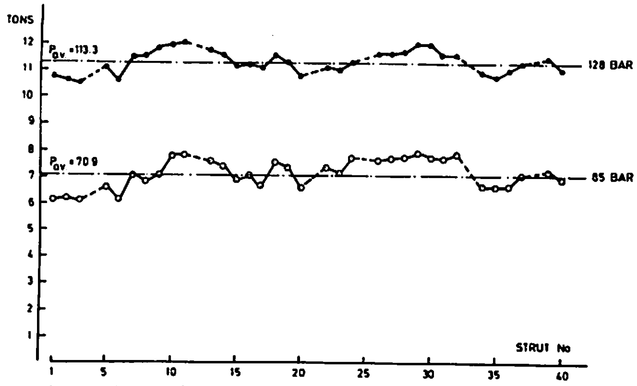


FIG.30 FORCE DISTRIBUTION IN LOCKING STRUTS

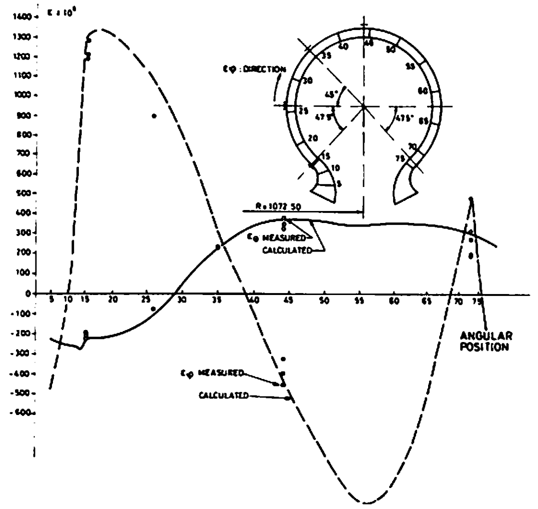


FIG. 31. STRAINS IN TOROIDAL SEAL, P = 85 BARS

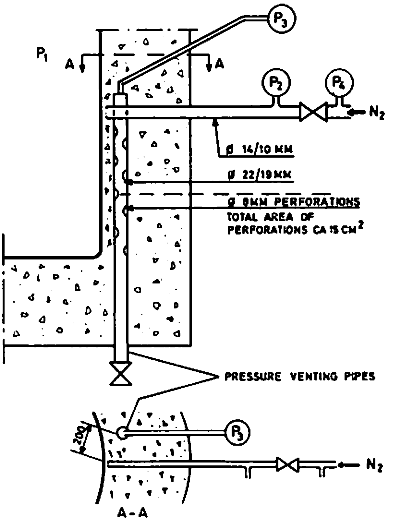


FIG. 33 TEST WITH PRESSURE BEHIND LINER

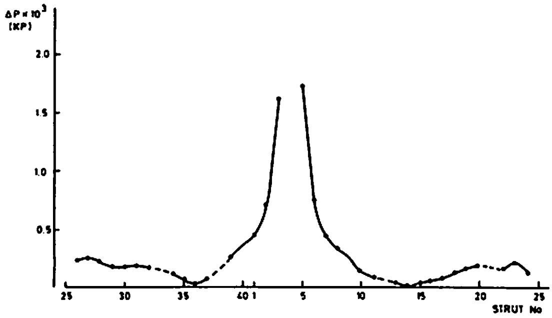


FIG. 32 CHANGE OF FORCE DISTRIBUTION IN STRUTS.
STRUT No 4 REMOVED. P = 85 BARS

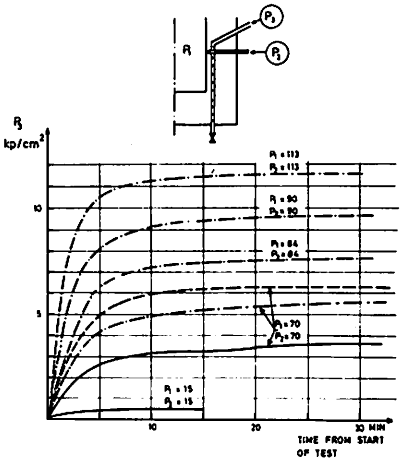


FIG. 34 PRESSURE IN THE PERFORATED PIPE

DISCUSSION

Q A. N. KINKEAD, U. K.

Could Mr. Andersen please enlarge on the strut accident case referred to in one of the final illustrations of his presentation as to how many struts were removed, etc. ?
I should also like to know whether the model tests confirmed that the strut loading remained sufficiently equalized in spite of the asymmetry of the vessel cylinder owing to its tendon anchorage abutments.
I should also be interested to know what accident case assumptions were made for the torus seal.

A S. I. ANDERSEN, Denmark

The accident case mentioned in the paper refers to the case where one strut, strut no. 4, is removed. We have done tests with two struts removed, no. 3 and 5. We found that the load in the remaining struts was well within the safety margin of the structure.
The load in struts shows some variation around the periphery, possibly due to manufacturing tolerances, friction in the prestressing and adjustment arrangement. Whether the asymmetry of the vessel has influences or not, has not yet been verified, but we intend to do so.
The stresses in the toroidal shell are calculated and are in good accordance with measured values. In our prototype studies we have a pressure dome on the top of the vessel and consider this is a safe design.

C P. H. MARGEN, Sweden

As a further comment to the question by the gentleman from the Dragon Project, I should mention that all struts are given a slight prestress by screwing down the wedges provided for this purpose to ensure that there is good contact everywhere and that each wall takes the same part of the load. This has worked well so that we have not obtained significant variations in the stresses when the vessel was put under pressure. Therefore the only accident we had to examine was the consequence of the failure of one or two struts. Regarding the question of a torus failure I should like to state that there are three lines of defence in our design: 1) the torus and double rubber seals, 2) a flow restrictor and missile protection on the inside of the torus and 3) the pressure suppression containment. As shown in the paper by Kraemer, H 6/7, no dangerous temperature transients occur if the torus fails and gas escapes through the flow restrictor to the containment. This has been confirmed by our model tests.

Q F. BREMER, Germany

1. In the paper it is stated that the viscoelastic behaviour of the model has been analysed by means of approximative methods. Could you give information concerning the simplification ?
2. Which types of crack detectors have been used ?

3. Is the French type of insulation (CAFL) used ? What is the experience with this insulation in water ?

4. The design seems to be very intelligent and ingenious but also very costly. Have investigations been made concerning the costs ?

A T. TARANDI, Sweden

1. The creep analysis has been made by introducing an approximate effective elastic modulus

$$E_e = \frac{E_o}{1 + \Delta T \cdot c \cdot E_o}$$

where E_o = instantaneous elastic modulus = 350,000 kp/cm^2.

ΔT = temperature difference between the actual temperature of the i-th calculating element and the room temperature, 20°C.

c = specific creep estimated from an article of Dr. England (1).

A simple loading history has been assumed. The loading conditions have been assumed to be constant during the time to the specific calculation time. For example, after the reaching of operating temperature, 10 hours after the start of heating up, the corresponding temperature distribution has been assumed to be existing during these ten hours, etc. ; of course internal pressure and prestress are included. Calculations have been made for the following times = 10 hr, 100 hr, 0.2 year, 1 and 30 years after the start. The main finding of these calculations is that the redistribution of stresses is greatest in the beginning of the loading history. After about one year at operating conditions the changes are quite insignificant.

Reference:

(1) G. L. England, "Steady-state stresses in concrete structures subjected to sustained temperatures and loads", Nuclear Engineering and Design, 3 (1966) pp. 54-65.

A S. I. ANDERSEN, Denmark

2. The crack detectors consist of a brittle wire, confined in a small tube. The wire is connected in series with an electrical bulb. Up till now we have not observed any crack with these crack detectors.

3. I have been concerned with the stress analysis and the evaluation of the structural tests of the insulation, and would like to refer to paper H 6/7, which will be presented this afternoon by Mr. Kraemer.

A S. MENON, Sweden

I would like to give some more details about the crack detectors. The detectors used in the Studsvik model have been developed by the Concrete Technology Department of the Swedish State Power Board. These detectors register the formation of cracks first at a width of 0.4 mm and then again at a width of 1.1 mm. For further information, please contact

Mr. Scherman
State Power Board - Dept. BT
Fack
162 87 Vällingby 1/Sweden

Regarding Mr. Bremer's fourth question:
Cost evaluations made on a concrete reactor vessel for a 750 MWe BWR indicate that a station with a Scandinavian PCRV shows a direct saving in plant costs of the order of 1 million dollar when compared to a station with a steel reactor vessel. To this should be added the savings due to a 6-8 months shorter building time. The above comparison has been based on the current Scandinavian ideas, where the PCRV is enclosed in a secondary pressure suppression containment similar to that for a steel vessel BWR.

C P. H. MARGEN, Sweden

As a comment to the last question raised by the chairman I wish to state that our removable lid design is not expensive. We have found indeed that it has interest not only for water reactors but also for the removable closure above the core of gas-cooled breeders and the removable pod-hole closures of HTGR's. Firms working on these gas-cooled reactors have been in touch with us on this subject.
Regarding the application to water reactors we feel that the step of going to a PCRV should be made as small as possible in order to get ready acceptance of the concept. For that reason we have kept the same station layout and containment and the same vessel internals as in a conventional steel vessel BWR, and we have designed a quickly removable lid to permit refuelling and maintenance to be done in the conventional way. Our Geneva conference paper, ref. (8) gives further details. By this policy of minimum change and very extensive experimental verification of the only new items (the lid, thermal insulation and certain pipe penetration), we hope to get the concept accepted.
The advantages compared to a steel vessel unit are above all in the field of safety due to the redundancy and progressive approach to rupture which will become especially important with the increasing interest in urban location of reactors, and the possibility to build vessels of any size, which should be important as unit sizes increase further in the industrial countries. Finally, as Mr. Menon mentioned, we found also a cost advantage which was a small percentage of the station cost (when the indirect cost advantage resulting from shorter construction time was neglected) but fairly large in relation to the cost of the vessel itself. The combined effects of these advantages and minimum change should provide a solid basis for exploitation of the concept.

Q J. M. BOISSERIE, France

Est-ce que vous pourriez donner un peu plus de détails sur le champ de contraintes au voisinage du couvercle à la lumière des 3 calculs qui ont été faits. En particulier pour le calcul fait à Swansea par le Professeur Zienkiewicz et ses collaborateurs ?

A S. I. ANDERSEN, Denmark

In the limited space available, it has not been possible to give all details about the different calculations. Further investigations will take place in connection with the evaluation during phase II of the experiment. We should gladly send you more detailed information, if you want so.