

Statement by CEO of ARPANSA on regulatory decisions arising from the misplacement of penetrations in the RRR pool tank

1. Introduction and Summary

1.1 Process of Regulatory Assessment

In early May 2003 ANSTO advised me that: 'due to a misinterpretation of drawings, the Reactor Pool liner as manufactured to date is not fully consistent with the approved detailed design. Specifically, the locations of a number of penetrations are incorrect.'

I was advised that unauthorised repairs had been carried out by the reactor tank and piping fabricator on some of the misplaced penetrations. A review of the information provided to me showed also that there had been significant delays in the errors being detected and the fabricator notifying JHEDI (the construction contractor) and then JHEDI notifying INVAP (the designer).

I wrote to ANSTO requiring that 'Further repairs of this error must not proceed until I am satisfied in this regard and I give written approval to proceed.'

In making the regulatory decisions arising from my examination of these matters, I examined the following documents:

- a submission from ARPANSA officers (the ARPANSA report - Attachment A). The ARPANSA report lists the complete documentation supplied by ANSTO on the matter and I examined those documents
- a report from CSIRO Manufacturing and Infrastructure Technology in its capacity as a consultant to ARPANSA (the CSIRO report - Attachment B)
- a report from Toshiba Corporation in its capacity as a consultant to ARPANSA (the Toshiba report - Attachment C).

The background to my examination of the incident and its consequences was the approval I gave for the manufacture of the Reactor Pool Liner and Services Pool Liner (RFA001) issued on 11 July 2002. This approval to construct an item important for safety was required as a condition of the construction licence and was based upon documents submitted by ANSTO in support of their request for approval.

In forming my view of the circumstances, I also took into account my discussions with the Nuclear Safety Committee, which was briefed on two occasions:

- at its meeting of 20 June 2003, where the error and the proposals for repair and associated issues were described
- at a special meeting on 14 July 2003, where the Committee was briefed on the investigation being conducted by ARPANSA officers to that date and their preliminary view of the material.

In this statement, I first describe the reactor pool and its safety role for the operation of the Replacement Research Reactor – the tank is effectively a Safety Category 1 item, the highest category.

I go on to describe the regulatory assessment process for approval for construction of items significant for safety and how this was applied in my approval to construct the tank and the ongoing effect of that approval.

I then describe the manufacturing errors that took place, the unauthorised repairs and the delays in notification by the fabricator and JHEDI. The proposed repair strategy is discussed.

I also assess whether there is any evidence of other unauthorised repairs and whether the same error affected other vessels constructed by the same fabricator

Finally, I discuss the implications of the matter for overall quality control of the Replacement Research Reactor Project.

1.2 Findings and regulatory decisions

After undertaking the assessment described in this statement, I make the following findings:

- the error made by the fabricator in rolling the plate inside out for the construction of the tank in all probability was the result of the fabricator applying a 'mental model' of how the convention of drawing a circular vessel applied, rather than examining the drawing sufficiently closely or asking for information
- the fabricator then made errors of judgement in carrying out unauthorised repairs and in not immediately raising a non-conformance report to be resolved by the designer
- the deficiencies in implementation of the QA system by the fabricator arose from lack of resources and a lack of an independent QA decision-maker. That these deficiencies existed also reflects on JHEDI as the construction contractor.

I have made the following regulatory decisions:

- The unauthorised repairs to three small holes in the lowest plate of the tank and the repairs in strakes 2 and 8 that required only additional plate and longitudinal welds have been undertaken consistent with the Code that formed the basis of my approval for construction of the tank. Therefore, I accept these repairs as being in conformity with my approval for construction of the tank.
- The repair criteria set out by INVAP (and accepted by ANSTO) in the document RRRP-0610-3BEDM-801-A together with
 - the revised welding procedure recommended to ANSTO by the Welding Technology Institute of Australia (WTIA)
 - the revised fabricator workshop organisation provided by ANSTO in its submission to me

will result in the repaired vessel being consistent with my approval for construction of the tank. Therefore, ANSTO may instruct the fabricator to proceed with the repairs to the other misplaced penetrations (whether unrepaired or previously repaired) on the basis of the INVAP criteria, the revised welding procedures and the changed workshop organisation.

- I wish to be assured that the repairs are carried out successfully and that all manufacture, repair and testing work has been fully documented. Therefore, I am applying two new licence conditions on the construction licence with the effect that:
 - the acceptance by ANSTO of the completed Reactor Pool tank shall be a 'hold point' requiring my approval before acceptance of the constructed tank may take place
 - ANSTO will obtain additional information about the welding of the tank as described in the ARPANSA report to be assessed at the time of the above 'hold point'.
- There are lessons learned from the incident and its consequences with regard to quality assurance systems across the entire RRR construction project (that is, including ANSTO, INVAP, JHEDI and sub-contractors). Therefore, I am applying a further licence condition requiring that ANSTO report as soon as possible and thereafter quarterly on the following matters as they apply to primary contractors and manufacturing sub-contractors for Safety Category 1 systems:
 - the resources applied to QA and the evidence of independence of QA decision-making from construction decision-making
 - the implementation of procedures for obtaining authorisation from INVAP for any changes to design documentation
 - the implementation procedures for dealing with 'non-conformance' reports
 - the implementation of inspection programs, including assurance that sub-contractors have personnel with a sound engineering understanding of the relevant requirements of the project.
- I will seek submissions from ANSTO on the licence conditions to ensure that they are formulated effectively to meet my intention.
- I will review the frequency and conduct of inspections by ARPANSA staff.

2. Background Information

2.1 The Reactor Pool Tank – function and process of manufacturing

The Reactor Pool Tank is an open cylindrical stainless steel tank, 14.1 metres in height and 4.5 metres in diameter. It connects through a transfer canal to the adjacent service pool.

A diagram of the tank is at Figure 1 of the ARPANSA report.

The Reactor Pool Tank will be embedded in a concrete block that will receive the loads acting on the tank.

The Reactor Pool Tank will contain:

- the nuclear core and associated structures
- the reflector vessel with irradiation positions, cold neutron source and neutron beam structures
- the water inventory required for the core and pool cooling systems to perform their functions.

The safety functions of the pool are to ensure that the primary cooling system has sufficient water to remove heat from the core by forced circulation during power operation and by natural circulation when shut down. The water also provides protection from radiation exposure to operating staff. The 'coolant boundary parts' of the tank are classified as Safety Category 1, Seismic Class 1 and Quality Level A. It thus must be designed, manufactured and tested to the highest standards.

As is clear from Figure 1, there are a large number of holes – penetrations – in the tank. These are for the operation of the cooling systems, for the beam tubes, to support the operation of the cold and hot neutron sources and to allow measurements of pressure and other purposes.

The tank is manufactured from a particular type of stainless steel (AS1 304L). It is not possible to fabricate a large vessel like this as a single piece. Rather the sides of the tank are manufactured from plates of stainless steel that are welded together. There are nine such plates, or strakes, making up the tank. Each strake is also not a single steel plate – so there are longitudinal welds joining the plates in a strake as well as the circumferential welds joining the strakes. The sides of the vessel are then welded to a base plate.

The overall design and construction is based upon an accepted vessel construction code – in this case American Society of Mechanical Engineers (ASME) 'Boiler and Pressure Vessel Code, Section III, Subsection ND'. This was the Code relied upon in the Preliminary Safety Analysis Report (PSAR) that formed the basis for my decision to grant a licence to construct the RRR. The Code is a distillation of engineering knowledge and experience about the design, materials selection, fabrication, inspection and testing of pressure vessels. Following the prescriptions in the Code will result in a vessel that will meet the strength requirements that it was designed for.

2.2 Construction Licence – approval of construction of items important for safety

Regulation 54 of the ARPANS Regulations 1999 imposes a licence condition on facility licences to the effect that the licence holder must not construct an item that is important for safety and that is identified in a safety analysis report unless the CEO has given approval to construct the item.

In issuing the licence to ANSTO for the construction of the RRR, I imposed licence condition 4.6, which effectively expanded on the condition imposed by Regulation 54 by setting out the process for obtaining approvals for items important for safety.

In seeking my approval for the construction of items important for safety, ANSTO puts forward a Request for Approval (RFA) that sets out the information sought in licence condition 4.6. This was the process followed for construction of the reactor pool liner. Since I issued the construction licence in April 2002, ARPANSA staff have completed assessments of more than 70 RFAs.

The information sought under licence condition 4.6 and provided in the relevant RFA is:

That the detailed design of the items has been

- i) completed in accordance with the design description and intentions in the Application; and*
- ii) reviewed, verified and accepted by the Licence Holder.*

This condition aims to ensure that the detailed design of the item is consistent with the description in the application to construct – that is, that it is consistent with the basis on which the licence to construct was issued. It also is a check as to whether ANSTO has taken control of the design put forward by INVAP. In assessing the RFA against these criteria, ARPANSA staff overview drawings and technical specifications and ANSTO's own review of these, particularly to see if there are major unresolved design issues. The RFA describes whether the design fully meets the description of the item set out in the PSAR. Where there are differences and these are important for safety, there needs to be a justification for the changed approach.

ARPANSA staff examine whether ANSTO has reviewed, verified and accepted the design, focussing on how matters raised by ANSTO with the designer have been dealt with by the designers.

That construction of the item will be:

- i) in accordance with the detailed design;*
- ii) under a certified quality assurance program;*
- iii) in accordance with a program that has been documented, reviewed and approved by the Licence Holder; and*
- iv) under a construction schedule that is made available to the CEO of ARPANSA.*

This condition first allows ARPANSA to be assured that the detailed design is detailed, complete and sufficient for manufacture and installation. In assessing the RFA against these criteria, ARPANSA staff direct attention to the inspection and test plans that are proposed and to the existence and certification of a quality system applying to the manufacturer of the item.

In terms of control over the construction of the item, this condition relies upon there being a certified quality assurance program applying to the manufacturer of the item.

I discuss the application of quality assurance to control of the construction of systems, structures and components in section 4 below.

In addition, ANSTO must demonstrate that it has taken into account recommendations set out in the Regulatory Assessment Report on the construction licence application that apply to the item in question. An RFA will list the relevant recommendations and provide a response, which is assessed by ARPANSA staff.

Once I (or the authorised ARPANSA officer) have considered an RFA, I then make a decision whether or not to approve construction of a particular item. The terms of the approval are very important as they instruct the licence holder as to the parameter of that approval and whether the approval is the subject of conditions (either contained within the approval or imposed as additional licence conditions). An example of the former is an approval which incorporates within it the requirement that ANSTO observe certain “hold points” in a construction process; an example of the latter is the requirement that in constructing a reactor vessel that ANSTO undertake 100% radiography of certain types of welds.

2.3 RFA001 – the reactor pool tank

ANSTO sought approval for the construction of the reactor and service pool tanks in RFA001, which was lodged with ARPANSA on 18 April 2002. After discussions between ANSTO and ARPANSA staff, an addendum to the Request for Approval was lodged on 18 June 2003.

On 11 July 2002, I wrote to the Executive Director of ANSTO approving the manufacturing of, inter alia, the ‘Reactor Pool Tank and Welded Parts (Subsystem 0610), but excluding the cut-outs for the heavy water pipes¹’. In doing so, I imposed the following additional licence condition:

Condition RFA 001-1

The Licence holder must ensure that all factory and on-site butt welds for the Reactor Pool Tank [_____] are subjected to:

- (a) 100 percent radiographic or ultrasonic testing; and*
- (b) 100 percent dye-penetrant testing.*

The reason for imposing this additional licence condition is that I had understood in the Application for the construction licence that such 100% testing was to be undertaken. This did form a basis for my approval of the construction licence. In the event, the ASME III Code selected by the designers for the construction of the tank did not require 100% inspection. I continued to believe that it was necessary to be consistent with the basis on which I had approved construction of the RRR.

¹ These cut-outs are in the bottom of the tank and are not relevant to this report. They were approved as part of a subsequent RFA.

3. The Errors and Proposed Repairs

The matters that I have examined are:

- i. the manufacturing error in the rolling of the plates that make up the Reactor Pool Tank.
- ii. the subsequent unauthorised repairs by the fabricator to the Reactor Pool Tank
- iii. the delay in notification by the fabricator of the manufacturing contractor
- iv. the delay in notification by the manufacturing contractor of the designer.

A detailed chronology of these events as supplied by the participants can be found in the ARPANSA report.

3.1 The Manufacturing Error

The records I have examined show that the steel plates for the Reactor Pool Tank arrived at the fabricator with the necessary penetrations already cut in them. Since not all the holes were symmetrically balanced in pairs, this meant that it was fundamental that the flat plates be rolled to form the cylinder of the tank in accordance with the design intentions. Instead, it would appear from all the accounts provided to me that they were rolled inside out.

The fabricator states that 'the manufacturing error occurred due to a misinterpretation of the Invap construction drawings' (NCR 017). I am advised by ANSTO that the drawings do indicate which way the plates should be rolled. This is achieved by the use of hidden-detail (dotted) lines to indicate features which are on the side of the plates remote from the direction of view. I understand that, however, the conventional approach in Australia differs from that adopted in the drawings and I conclude that the rolling was undertaken on the basis of convention, without sufficiently close examination of the drawings.

As a result of this incorrect rolling, 24 of the 95 penetrations were in the wrong place in the Tank.

3.2 The Unauthorised Repairs

Having discovered the error, the fabricator carried out the following repairs:

- i. two plates within stakes 2 and 8 were cut, repositioned and new plate welded in to correct the position of two large holes in these strakes.
- ii. ten other holes were repaired by welding material into the holes. These repairs included three small holes sited together in the bottom strake, where the repair approach was to cut out a semi-oblong area around the holes and to weld new plate in the same shape, prior to the welding of the bottom strake to the base-plate of the tank.

In the documents supplied by ANSTO, the fabricator put the view that undertaking the repair (i) was consistent with the ASME Code and did not require any prior authorisation by the designer. Records of the materials used and the welding methods were kept at the time and the additional welds were radiographed – just as was done for all other longitudinal welds in the fabrication. ARPANSA officers have examined these records.

The fabricator states that the repairs (ii) were carried out to test the repair process so that a rectification process could be put forward when the non-conformance report was raised. ANSTO's submission to me was that insufficient records were made of these repairs at the time they were carried out.

3.3 Delays in Notification

As described in the ARPANSA report, the error was first recorded in a non-conformance report raised internally by the fabricator on 19 February 2003, but was not advised to JHEDI or INVAP. The first of the unauthorised repairs was carried out in early March, with the remaining unauthorised repairs done in the latter part of March.

JHEDI was advised of the matter by the fabricator on 17 April – that is, some weeks after the unauthorised repairs were completed. JHEDI did not inform INVAP until 6 May (verbally) and JHEDI and INVAP received a formal non-conformance report on 8 May.

As noted above, the fabricator argues that they could make the first repairs, without seeking design approval. The repairs to the ten other penetrations were said by the fabricator to be done as trials of the approach so that they would be able to approach JHEDI and INVAP, not just with a problem, but with a solution at hand.

Material gathered by JHEDI and INVAP during an inquiry conducted by them into the events and subsequently reported to ARPANSA refer to certain personal reasons affecting staff of the fabricator and JHEDI, which assist in understanding the human reasons for the delay in communication. However, this information is not offered as an excuse, rather as an explanation.

Both the delay in the fabricator notifying JHEDI and JHEDI in notifying INVAP are described by JHEDI and INVAP and acknowledged by the fabricator as being unacceptable breaches of the quality control procedures. An audit of the QA procedures at the fabricator subsequently carried out by INVAP confirmed poor compliance by the fabricator with the quality system in force. The audit identified the focus on certain individuals and the lack of independent QA decision-making as being important root causes.

Having reviewed the evidence, I am prepared to accept the fabricator's view as to why they undertook the unauthorised repairs – it was, however, poor judgement. I believe that the further delays in notification, even after the repairs were completed, are likely to be a reflection of the pressures that the fabricator was under at a time when a great deal of pipe-work was urgently being required to be completed. I

accept, then, that insufficient resources and a lack of sufficiently independent QA decision-making are the root causes of the poor decisions. The fabricator cannot take all the blame for this situation, which I discuss further later in this statement.

3.4 The Proposed Repairs

The repair strategy put forward by INVAP and accepted by ANSTO for the **unrepaired** misplaced holes is as follows:

- holes smaller than 100 mm diameter will be enlarged to a diameter of 100 mm
- enlargement of holes will be made so as not to intersect with existing welds
- if the enlarged holes would be closer than 25 mm to each other than a single enlarged hole will be made to prevent such occurrence
- the edge of any repair will be at least 25 mm from any other penetration
- the edge of the repair will be at least 25 mm from any other weld or it will be extended to replace the other weld
- welds will not be under a penetration reinforcement patch.

For the **repaired** holes, the strategy is that, with the exception of the area where the three small holes in the bottom strake were repaired, the holes will be re-repaired using the criteria applied to the un-repaired holes. The heat affected zones around the repaired holes will be removed.

The basis for this repair strategy is to limit the heat input into small areas of the stainless steel plate by enlarging the small holes and by avoiding overlapping of heat affected zones from different welds.

The repairs will be subjected to a range of non-destructive testing as described in the ARPANSA report.

In the first submission to me dated 16 June, ANSTO and INVAP proposed to re-repair the repaired area in the bottom strake. Given that the fabricator's repair had cut out an area around the three holes, the issue here was not a concern that there may have been excessive heat in a small area. Rather it was that the necessary supporting quality documentation for the repair was not available.

Subsequently, documentation of the original repair was offered and on the basis of this documentation it is now stated by ANSTO that the repair was carried out in accordance with the Code. The documentation is essentially a reconstruction drawing upon the welding 'diary' kept by the then welding supervisor. I did carry out an inspection of the fabricator's premises and had discussions on and observe the system of documentation of welds. I accept that it is possible to draw upon the weld supervisor's diary in the manner in which it has been done and that this should produce an authentic record. The welding is subject to 100% radiographic inspection.

ANSTO and INVAP accept that the additional work on the plates in strakes 2 and 8 was not a 'repair' in the sense of the Code, but could be regarded as new work. It

was carried out consistent with the Code and supported by the necessary documentation. On the basis of the ARPANSA report, I agree with this assessment.

3.5 Assessment of the Proposed Repair Strategy

In order to be satisfied that the repair welding will not adversely affect the stainless steel material, I need to consider: sensitisation, hot cracking, embrittlement and control of distortion. These terms are defined in the ARPANSA report – the fundamental issue is whether the stainless steel material becomes damaged so that it is of significantly higher risk of corrosion or failure over the expected life of the tank.

These matters are reviewed in substantial detail in the ARPANSA report, the CSIRO report and the Toshiba report as well as in a report from the WTIA prepared for ANSTO. The Nuclear Safety Committee also addressed the matters.

In brief, the CSIRO report reviews the repair strategy against the known issues for the weldability of stainless steels. In particular, the CSIRO carried out tests on circular patch welds using the same materials as are used for the tank and the same welding filler material. These tests included metallographic examination of sections of the welds. The CSIRO report concludes that the proposed repair strategy for the misplaced penetrations is adequate and will have the same effects on material behaviour as other construction welds, provided that the heat input and residual stresses are minimised.

Again in brief, the Toshiba report views the repairs effectively as new work under the Code that can effectively be carried out, subject to consistency with the requirements of the Code.

Will the repaired vessel have the same structural integrity as the original designed vessel? There seems to be little doubt about this – the welds themselves throughout the vessel are determined as having a ‘weld efficiency factor’ of one – meaning that the welded joint is as strong as the parent metal surrounding it. The weld efficiency factor 1 is assured because of the type of welded joint and the 100% radiographic examination required by the licence condition. The tank was designed against the Code on the basis of a weld efficiency factor of 0.7 – so it is very conservatively designed in view of the higher weld efficiency factor achieved.

Therefore I approve the repair strategy for the un-repaired holes and repaired holes (with the exception of the three repaired holes in the bottom stake that are dealt with below) as set out in on the basis of the repair criteria set out by INVAP in the document RRRP-0610-3BEDM-801-A, together with the weld preparations recommended by the WTIA.

There seems to be no debate about the ‘repairs’ carried out on strakes 2 and 8 – they do no more than add two longitudinal welds. I have no difficulty in accepting that they are consistent with my original approval of RFA 0001.

Turning then to the repaired holes in the bottom strake, the proposal is that this should also be accepted as being consistent with my approval of RFA 0001. The documentation supporting the proper carrying out of this repair is based upon the welding supervisors' diary, a copy of which has been supplied by ANSTO.

The original proposal by INVAP was also to re-repair this repair. But there were difficulties in this, particularly with regard to re-welding the patch to the bottom of the tank. I believe that if a re-repair could be avoided in this case, it would be desirable option. In other respects it fills the criteria for repairs established by INVAP. The repair did not use the revised welding technique recommended by the WTIA – but it has been inspected for distortion and is subject to 100% radiographic inspection and other tests. The CSIRO report recommends accepting the repair after obtaining proof that all the steps of the repair process were carefully monitored and the quality of the welds is adequate. The measures that have been taken achieve this proof.

3.6 Quality Control of Repairs and Further Fabrication of the Tank

As I noted above, I believe that the root cause of the events following the manufacturing error was lack of resources in the fabricator and an inadequately supported QA system. There has been a very substantial re-organisation of the working arrangements, quality assurance process and supervision of the fabricator, with an injection of experienced personnel from JHEDI. The roles and functions of these personnel have been described, as has their qualifications. ARPANSA staff assess the revised arrangements as being very strong in terms of control of the repairs and further fabrication.

Lying behind these arrangements is a legal agreement between the fabricator and JHEDI. I am assured and accept that the new management control structure is consistent with the legal agreement and enforceable.

Once the construction of the tank is complete, INVAP and ANSTO need to accept it based upon their review of all the documentation describing its construction. This will include, of course, full documentation of the repairs and the testing and inspection results for them. In the circumstances, it would seem appropriate that this position also be a 'hold point' for ARPANSA. ARPANSA staff will then participate in the final review of the documentation and construction and advise me as to whether the constructed tank meets the requirements of my approval for its construction. I am applying a licence condition to this effect.

3.7 Related Issues

Having regard to these circumstances, I wanted to be satisfied that there were no other unauthorised repairs that had been undertaken on the vessel and not revealed. An ARPANSA inspector took part in a close examination of the tank for this purpose. The exterior of the tank is covered by a protective sheet of plastic. The ARPANSA inspector verified that it was not possible to remove and relay the plastic, without this being evident on examination. Where the sheeting had been disturbed for some

reason, the surface of the tank was carefully visually examined. This would have revealed any repairs and none were found.

The fabricator has manufactured other vessels for the RRR Project. Clearly, if the incorrect rolling of the plates for the reactor pool tank arose from the 'Australian' interpretation of drawings of flat plate to be rolled into a vessel, then the same thing would have happened to all of the vessels manufactured by the fabricator. If there were asymmetric penetrations in these vessels, then the possibility is that they may have been displaced in a similar fashion as happened to the reactor pool tank.

I sought a full listing of vessels manufactured by the fabricator and whether there were misplaced penetrations. The table supplied by ANSTO is as follows:

Item	Status	Misplaced Penetrations
0610-RPO-001 Reactor Pool	In manufacture	Yes. NCR 017 refers.
0710-SPO-001 Service Pool	In manufacture	No
0780-TCA-001 Transfer Canal	Not started	No
1050-BR-001 PCS Decay Tank	In manufacture	No
1350-BR-001 RSPCS Decay Tank	In manufacture	No
1110-BR-003 Heavy Water Storage Tank	Awaiting acceptance	No
5220-BR-001 Radioactive Liquid Waste Tank 1	Awaiting acceptance	No
5220-BR-002 Radioactive Liquid Waste Tank 2	Awaiting acceptance	No
6252-BR-001 CNS Helium Relief Tank	Accepted	No
6254-BR-001A CNS Deuterium Buffer Tank A	In manufacture	Yes. Engineering Modification Sheet RRRP/6254/IN/003 refers.
6254-BR-001B CNS Deuterium Buffer Tank B	In manufacture	Yes. Engineering Modification Sheet RRRP/6254/IN/003 refers.

ANSTO states that the walls for the two Deuterium tanks in the table were apparently rolled inside out resulting in one 150 mm penetration being incorrectly located in each vessel. ANSTO advises that the fabricator wrote to INVAP in early March 2003 with proposals for rectification of these misplaced penetrations. INVAP replied in mid March accepting the fabricator's proposal, noting that 'the rework carried out in accordance with the attached procedure does not affect the function of the vessels.'

4. Lessons for Quality Control of the Project

4.1 The QA System for the Reactor Project

Consistent with international best practice in radiation protection and nuclear safety and reinforced by conditions of licence, the Replacement Research Reactor is designed and constructed within a quality assurance (QA) system. The application of quality assurance to nuclear installations is described in the IAEA Safety Series 50-C/SG-Q : 'Code for Quality Assurance for Safety in Nuclear Power Plants and Other Nuclear Installations'.

Very briefly, QA systems are systems of work designed to result in very predictable and reliable outcomes that meet customer and regulatory requirements. The IAEA Code sets out ten 'basic requirements' covering QA program, training and qualification, non-conformance control and corrective actions, document control and records, work, design, procurement, inspection and testing for acceptance, management self-assessment and independent assessment.

The approach to QA for the Replacement Research Reactor project is described in the Preliminary Safety Analysis report (PSAR) that was submitted with ANSTO's application for the licence to construct the reactor, particularly in Chapter 18. The PSAR refers to the IAEA Code and describes the QA system applying in each of the principal organisations: ANSTO, INVAP and JHEDI and how they interact.

Each of the QA systems is certified to the international standard ISO 9001:1994 and subject to internal and external audits.

As noted above, licence condition 4.6 requires that the manufacture of any item important for safety be undertaken within a certified quality assurance program. This is consistent with the overall project QA plan. The fabricator of the tank operates a QA system accredited against ISO 9002:1994 (the international model for QA in production, installation and servicing).

An important part of QA in the process of manufacturing items is the Inspection and Test Plan (ITP) that is prepared during the detailed design and accepted by ANSTO. Such plans exist at high level for the entire Replacement Research Reactor project and specific ITPs are prepared for the construction of each item. The ITP sets out points during the construction where there must be a check on the achievement of the particular phase of the construction against defined reference documents and a 'sign-off' by the appropriate person that the work meets defined acceptance criteria. The ITP may allow for participation in the process by the fabricator, JHEDI, INVAP, and ANSTO. ARPANSA also may choose to be involved as a means of monitoring compliance with the licence.

While it is the ultimate goal of QA that the right job is done right the first time, it is recognised that matters will arise that are not fully consistent with the requirements set out in the design and construction documents. The proper handling of such 'non conformances' is a vital part of a QA system. The idea is that the matter is brought to

attention of all relevant parties in a timely manner and resolved by the appropriate authority with the outcome properly recorded. Sometimes this is simple – a flaw is found in a weld by radiographic inspection; the weld is repaired and re-radiographed; and the repair is recorded in the documentation. In the matter under consideration, however, resolution of the non conformance by the fabricator was not appropriate, the designer needed to assess the circumstances and determine the approach to resolving the matter.

4.2 Assessment of the errors against QA system

I am advised that the drawings that were relied upon by the fabricator to manufacture the tank do indicate the way in which the plates should be rolled. That is, they explicitly show whether one is viewing the inside or outside of the tank when viewing the two dimensional drawings.

To the extent that the drawings did indicate the direction of rolling, INVAP may be excused from any deficiency in the provision of appropriate documentation for the construction of the vessel. The root cause was the fact that these indications were not taken account of, probably due to a 'mental model' on the part of the fabricator that interpreted the drawings in the Australian convention, without paying sufficient attention to the drawings.

I then turn to the matter of resolution of the non conformances that flowed from the initial mistake.

Under the QA system that applied, the error should have immediately been notified to JHEDI and in turn to INVAP in a timely manner.

Taking the explanations made by the fabricator at face value, it would seem that they took the view that the final decision on the repairs made to strakes 2 and 8 was within their capacity in terms of the Code and the QA system. The other repairs were characterised as experiments to test if a repair strategy was appropriate.

That these decisions to carry out unauthorised repairs and not to notify the errors immediately were able to be made by the fabricator, while it shows a lack of proper judgement, also shows that the QA system was not at all effectively implemented. That this was so can also be partly laid at the feet of JHEDI as construction manager. JHEDI should have assured itself of the adequacy of implementation of QA by the fabricator.

The fact that JHEDI, when notified of the matter, did not take action to bring the matter to INVAP's attention until several weeks had elapsed is also an egregious error and must be inconsistent with any proper QA.

After the event, INVAP conducted an audit of the QA system applying at the fabricator. That audit concluded that the events, including the non-conformance not being notified and approved by JHEDI/INVAP, were not consistent with ISO 9002:1994 and the fabricator's own Quality Plan. The audit also pointed to other shortcomings of implementation of the fabricator's Quality Plan.

A further INVAP review of the non-conformance report on the matter refers to fourteen 'corrective and preventive' actions ordered by INVAP. The majority of these refer to the particular circumstances involving the fabrication of the reactor tank and have been implemented in that context. A number would seem to be of general applicability and I set them out with my own paraphrasing and additions as follows:

- All changes proposed by JHEDI and its subcontractors to the approved INVAP design documentation shall be raised immediately using the established Request for Information (RFI) and Change Advice Note (CAN) system. No changes are to be made to the approved INVAP design documentation prior to receiving an approved CAN.
- Where deviations are discovered during the in-process inspections defined in the approved specific Inspection and Test Plans (SITP), a Non-Conformance Report shall be raised immediately and submitted to INVAP
- Sign-off of SITPs to be reviewed to agree how control is to be maintained and recorded when part fabrication is completed prior to moving onto the next step in the fabrication process
- The JHEDI QA team should be strengthened for all suppliers and the importance of suppliers working in complete compliance with QA procedures is to be stressed.
- There should be more frequent inspection visits by JHEDI and INVAP staff to all subcontractors.
- As part of the inspections, the effective separation of QA and construction personnel will be stressed, as will assessment of the engineering understanding of the design requirements.

I believe that these matters represent the lessons learned from these events that are applicable to the QA control of the entire project. The documents supplied by ANSTO give some indication that these lessons are being applied to the project as a whole. I intend to establish this on a formal basis by applying a licence condition on the construction licence that requires a report on the implementation of the QA lessons learned on an ongoing basis for manufacture of Safety Category 1 systems.

John Loy
CEO of ARPANSA
26 August 2003